University of Alberta

Effects of Creatine Monohydrate Supplementation on Body Composition and Strength Indices in Experienced Resistance Trained Females

by

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ABSTRACT

The purpose of this study was to examine 9.5-weeks of creatine monohydrate (Cr) supplementation coupled with resistance training on body composition and strength in female trainees. Twenty-six participants ingested Cr or placebo (Pl) at a dose of 0.3g/kg and 0.03g/kg body mass for the initial 7 days and subsequent 58 days, respectively, while performing a 4-day/week resistance-training program. Significant increases ($p<0.05$) occurred in both groups for lean body mass and 1 RM bench press (BP) and incline leg press (ILP). There was no significant difference in the number of repetitions completed for a 5 set 70% 1 RM repeat protocol for both BP and ILP for both groups, nor the ability to perform a greater training volume (sets x repetitions x load) over the 9.5 weeks. The results indicate that 9.5-weeks of concurrent resistance training and Cr supplementation does not improve strength or lean body mass greater than training alone.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Creatine monohydrate is a nutritional supplement that has gained media attention and popularity with many individuals who are looking for an ergogenic advantage over other competitors. One of the potential effects of creatine monohydrate is an increase in lean body mass as a result of myofibular protein synthesis, that when coupled with a resistance training program, can maximize training gains (Haff et al., 1999, Gibala, 2000). By incorporating a resistance training program while supplementing with creatine monohydrate, the individual should see larger increases in muscular strength and lean body mass than through creatine supplementation alone.

The depletion of muscle phosphocreatine stores is associated with the development of fatigue during short-term, high-intensity exercise. This depletion results in an inability to produce energy at the rate required, which in turn attenuates the force needed to generate the muscle contraction. Therefore, creatine in its free and phosphorylated forms plays an important role in regulating energy metabolism in skeletal muscle (Hultman et al., 1995). By supplementing with creatine monohydrate, individuals may increase their muscle creatine stores and have more energy available during times of maximal exercise. The preponderance of research indicates that creatine ingestion can significantly increase short-term high-intensity, repeated bouts of exercise performance by delaying the onset of muscular fatigue (Hultman et al., 1995).

1.2 Statement of problem

There have been concerns expressed in the relevant literature that results which are based on male subjects in relation with creatine supplementation may not be generalizable to females. It is important that females are included in the library of literature as both female athletes and the general female fitness enthusiasts need reliable information in order to make educated decisions about whether a supplement will enhance their training regimes and improve body composition (Ferreira, 1999).

1.3 Contribution to the field

To the best of the investigator's knowledge there have been only eight studies that have used females exclusively as participants with a creatine supplementation protocol (Vandenberghe et al., 2000, Larson-Meyer et al., 2000, Brenner et al., 2000, Chilibeck et al., 1998, Cox et al., 2002, Hamilton et al., 2000, Ledford et al., 1999, Stout et al., 2000). Only one of these studies has used dual energy x-ray absorptiometry (DEXA) (Larson-Meyer et al., 2000) as a method of body composition assessment. The majority of these studies have used an acute supplementation protocol, which consisted of a time period of two to seven days. This study utilized a longer-term creatine supplementation protocol (9.5 weeks) with experienced resistance trained females as participants along with DEXA to assess body composition changes. This research was one of the only studies to use a sufficient number (26) of experienced resistance trained females, along with using a 70% 1 RM, 5 set repeat protocol to determine what effect creatine monohydrate supplementation had on high intensity, repeat sets. Not one of the aforementioned studies has used a significant number of participants (maximum number of subjects

per group was 12) to minimize the amount of Type II error during statistical analysis. It is suggested that a minimum number of 15 participants per group be used or a power calculation should be administered to determine what number of subjects would elicit a significant response (Tarnopolsky & MacLennan, 2000, Plisk & Kreider, 1999). Considering there is very limited research done with female subjects and creatine supplementation, this study would improve our understanding of the effects on women's strength and body composition measures during a resistance-training program while supplementing with creatine monohydrate over a longer term period.

1.4 Purpose

The purpose of this study was to measure body composition changes and strength indices when combining a 9.5-week resistance training program with creatine monohydrate supplementation in females who were experienced recreational weight lifters. It was hypothesized that the participants who were receiving the creatine supplement and concurrently resistance training, would have greater increases in muscle mass and strength measures than those who were receiving a placebo supplement and resistance training. Secondly, it was also hypothesized that those participants who were ingesting creatine monohydrate would be able to endure a greater load or volume of work during the training periods than those training with the placebo.

1.5 Delimitations

Eligible female subjects were recruited from the University of Alberta and Edmonton area population. The criteria needed for participation in the study

included: a minimum of one year of resistance training experience (at least 2-3 times per week); between the ages of 18 and 35; had not used any form of nutritional supplement six weeks prior to the initiation of the study; must have consumed a mixed diet (no vegetarians) and must have been able to undertake a non-supervised 9.5-week resistance training and supplementation program.

The independent variables in this study included the treatment of supplementation (creatine monohydrate verses placebo) and resistance training load. The dependent variables assessed were body composition, including total body mass, fat free mass and fat mass and strength, one-repetition maximum (1 RM) and repeated multiple set 70% of 1 RM utilizing bench press and incline leg press protocols and training volume.

1.6 Limitations

1. Participants for the study were not randomly selected from the population; subjects were recruited through advertisement (posters or word of mouth).
2. Consumption of the supplement and adherence to all prescribed workouts was self-reported and was not supervised.
3. Not all subjects performed the exercise sessions at the same facility.
4. Dietary logs were self-reported and may not have been recorded accurately, and therefore could have misconstrued the results of actual caloric intakes of subjects.
5. DEXA is not a direct measure of body composition, and equipment error must be considered when analyzing results.

6. Subject's level of motivation could not be controlled during the strength testing measures, although motivational encouragement was provided throughout the study.
7. Urinary analysis is an indirect measurement of creatine uptake into skeletal muscle as opposed to a direct method such as a muscle biopsy.
8. Subjects may not have collected all urine during the 24-hour periods that were to be completed throughout the study.
9. Even though the subjects were informed to abstain from caffeine ingestion during the loading phase of the study, their behaviour could not be controlled.
10. One of the possible side effects of creatine supplementation is rapid weight gain, which may interfere with the double blind procedure. However, according to Lemon (2002), weight gain in women is not as significant as in men, which may attenuate this effect from being as noticeable.
11. Approximately 20-30% of the human population are "non-responders" to creatine supplementation, which indicates that these subjects will not uptake creatine into the skeletal muscle, but rather excrete it through the urine (Greenhaff, 1994). Jacobs (1999) also stated that individuals can vary widely in their physiological sensitivity or response to either pharmacological or nutritional treatments, and therefore not everyone will "respond" to creatine.

12. The timing of the menstrual cycle was not accounted for in this particular study, but was recorded during times of testing measures.

1.7 Definitions of appropriate terms

Experienced resistance trained females: Females who have been actively weight training for a minimum time period of one year, on an average of 2 to 3 days or more per week.

2-for-2 rule: If a participant can perform two or more repetitions over their assigned repetition goal in the last set in two consecutive workouts for a certain exercise, then additional weight should be added to that exercise at the next exercise session. (Baechle & Earle, 2000).

One repetition maximum (1RM): The greatest amount of weight that can be lifted with proper technique for only one repetition (Baechle & Earle, 2000).

Volume: The total amount of weight lifted in a training session(s). It is calculated by multiplying the number of sets by the number of repetitions times the load lifted per repetition (Baechle & Earle, 2000).

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CHAPTER 2

REVIEW OF RELATED LITERATURE

2.1 Introduction

Creatine (methylguanidine-acetic acid), a nitrogenous amine, is a naturally occurring constituent found primarily in meat and fish. It can be consumed in the diet or endogenously synthesized in the body (Williams et al., 1999, Volek & Kraemer, 1996, ACSM, 2000). Individuals who consume a normal omnivorous diet, whose protein intakes range from 1 to 2 $g \cdot kg^{-1} \cdot d^{-1}$, would ingest approximately 0.25 to 1 $g \cdot d$ of creatine from their diet (Williams et al., 1999). Dietary ingestion combined with endogenous biosynthesis, meet the daily turnover rate of approximately 2 g of creatine daily (Haff, 1999).

When creatine is ingested, it is absorbed unchanged from the lumen of the intestine and passes directly into the blood stream (Williams et al., 1999, Clark, 1997). An increase in dietary creatine ingestion will reduce the amount of creatine synthesized endogenously (ACSM, 2000). Creatine can be produced within the body in the liver, pancreas and kidneys from amino acids glycine, methionine and arginine. It is then transported to skeletal muscle, the heart and the brain where it is used as an energy source (Clark, 1997, Plisk & Kreider, 1999, Silber, 1999, Volek & Kraemer, 1996).

2.2 Creatine as an energy source

Creatine is used in muscle for energy production and is then converted spontaneously and nonenzymatically to creatinine. Creatinine cannot be used by skeletal muscle, and therefore it is diffused out the cells and excreted by the kidneys

through the urine (Clark, 1997). Since creatine has a low molecular weight, this removal process is completed with no required energy expenditure (Hultman, 1995, Plisk & Kreider, 1999).

Approximately 95% of creatine found within the body is located in skeletal muscle, with the remaining 5% being distributed to the heart, brain and testes (Haff, 1999, Volek & Kraemer, 1996, Williams et al., 1999). Within the skeletal muscle, approximately 60 to 70% of total creatine binds to a phosphate molecule, creating phosphocreatine (PCr). The remaining 30 to 40% of total creatine is found in free creatine form (Cr) (Haff, 1999, Volek & Kraemer, 1996, Williams et al., 1999).

2.3 Creatine concentrations within the muscle

It has been suggested that muscle creatine concentration may vary between individuals, with an average intracellular total creatine concentration of approximately 120-125mmol/kg dm (dry mass). Studies have found a maximum intracellular total creatine concentration of about 160 mmol/kg dm after supplementing with creatine for a number of days and/or weeks (Clark, 1997, Plisk & Kreider, 1999). It seems that the lower the initial muscle creatine concentrations, the greater the increase of creatine concentration in skeletal muscle with creatine supplementation, and vice versa. If an individual has an initial higher level of intracellular creatine concentration they will uptake less of the creatine supplement into skeletal muscle (ASCM, 2000, Haff, 1999, Clark, 1997, Plisk & Kreider, 1999).

The human body has a natural limit for the amount of creatine it will store in the body. Creatine supplementation or ingestion will not increase muscle creatine content beyond the body's natural limit. It appears that the maximum intracellular

total creatine concentration is approximately 160 mmol/kg dm (dry mass) (Clark, 1997, Plisk & Kreider, 1999). Once the muscles have reached this maximum level, creatine will be converted to creatinine and excreted in the urine (Hultman, 1995, Clark, 1997).

2.4 Creatine supplementation protocols

Creatine supplements come in forms of powders, candy, gum, liquids, chewable tablets and sports bars. The ergogenic aid industry has individualized the supplementation process by expanding the number of ways that the supplement may be ingested.

Generally, there are two phases that occur when supplementing with creatine monohydrate. The first phase is known as the loading phase and its purpose is to ensure that the individual's muscle fibres have maximally uptaken as much creatine monohydrate as possible. This is achieved in one of two ways. The loading dose can be given as an absolute dose of 20 to 30 g/d^{-1} or a relative dose, based on the individual's total body mass, of 0.3 $g/kg/d^{-1}$, both for a 2 to 7 day period (ACSM, 2000, Haff, 1999, Hultman, 1995, Wyss, 2000).

The second phase is referred to as the maintenance phase and its general purpose is to ensure that small amounts of creatine monohydrate are ingested in order to retain the maximal stores that have been achieved within the skeletal muscle during the loading phase. During this phase the individual can ingest a general dose, or it can be based on body weight as well. An amount of 2 to 3 g/d^{-1} or 0.03 $g/kg/d^{-1}$ is taken for a term of least 28 days (Haff, 1999, Hultman, 1995). Following cessation of supplementation, there is a "wash-out" period of approximately 4 weeks in order for

the body to return to pre-creatine supplement levels and to normalize the endogenous biosynthesis levels.

2.5 Enhancement of Creatine uptake

There are two ways in which creatine uptake into skeletal muscle can be enhanced. One method is through carbohydrate ingestion. According to the ACSM and Haff (2000, 1999), muscle creatine accumulation can be significantly increased by ingesting large quantities of carbohydrate simultaneously which is mediated by a glucose-stimulated release of insulin. This seems to reduce the variation of creatine supplementation response in individuals. The simultaneous ingestion of carbohydrate results in greater total muscle glycogen concentrations and total creatine muscle content (Nelson et al., 2001).

Creatine loading can be compared to carbohydrate loading. The objective of carbohydrate loading is to increase glycogen stores in the muscle in order to delay glycogen depletion during exercise, which in turn, enhances performance. If creatine intake is increased in order to enhance phosphocreatine storage, phosphocreatine depletion is delayed and therefore, performance may be enhanced (Volek & Kraemer, 1999). Researchers have suggested that inducing insulin and other hormonal responses through caloric, protein and carbohydrate supplementation will enhance anabolic processes stimulated by resistance training (Burger, 2002).

There seems to be equivocal research in the area of fuel metabolism and gender, and certain data has suggested that men and women may place different priorities on lipid and carbohydrate utilization during exercise (Horton et al., 1998). This concept may be transposed to the creatine loading phenomenon in which males and females

may not respond similarly to creatine monohydrate ingestion. Horton et al., (1998) found that there was a gender-specific difference in the prioritization of fat and carbohydrate fuels for oxidation during exercise. Women had greater relative fat oxidation and lower relative and/or carbohydrate oxidation than men in this study. Horton et al., (1998) suggested that increasing glycogen stores to enhance performance may be less effective in women than in men. Therefore, it may be reasonable to hypothesize a similar response in regards to creatine loading and females.

The second method of increasing creatine uptake within skeletal muscle is through exercise. This may be due to total increased blood flow or a change in transport kinetics of creatine across the muscle cell membrane (Harris et al., 1992). By ingesting creatine and carbohydrate simultaneously, while concurrently exercising, creatine should produce a maximal reaction within skeletal muscle, therefore eliciting the greatest response by the individual.

2.6 Creatine supplementation and fibre typing

Type II fibres have higher initial levels and greater rates of utilization of phosphocreatine and glycogen than Type I muscle fibres. Individuals (or muscles) with a higher percentage of slow twitch (Type I) fibres will respond better to creatine monohydrate supplementation (Hespel, 2001). However, Syrotuik and Bell (2004) noted that the greatest response occurred in those subjects with a higher percentage of Type II fibres. Phosphocreatine recovery is slower in Type II fibres, which likely contributes to a decrease in force production during high intensity, short term exercise (Volek & Kraemer, 1996). Based on this information, it is apparent that not all

individuals will respond to creatine supplementation in the same regard. An individual's muscle type composition appears to determine how well they may respond to a supplementation period (Syrotuik & Bell, 2004).

2.7 Responders vs. non-responders

One of the most important determinants for responsiveness to creatine monohydrate supplementation is an individual's initial muscle creatine content (Hespel, 2001). Greenhaff (1994) has suggested that approximately 20-30% of the population do not respond well to creatine supplementation. He also recommended that it may be necessary to increase total muscle creatine by close to 20mmol·kg^{-1} dw in order to obtain significant improvements in exercise performance as a result of creatine ingestion.

Syrotuik & Bell (2004) have stated that there are two important variables that will help determine an individual's ability to respond to creatine monohydrate supplementation. These include muscle fibre type composition and the initial cross-sectional area of the muscle fibres. Syrotuik & Bell (2004) found that "responders" had the greatest percentage of Type II fibres and a larger initial cross sectional area for Type I, Type IIa and IIb fibres. They suggested that the initial fibre size and cross-sectional areas would favour a greater potential to increase storage of creatine monohydrate within the fibre. Forsberg (1991) found that females have smaller cross-sectional areas, especially in fast twitch fibres, than males. Based on the above information, it may be assumed that females may respond to creatine supplementation to a lesser extent than their male counterparts.

2.8 Side effects of creatine supplementation

The only reported side effect from creatine monohydrate supplementation has been weight gain, from studies using up to 25 g/d^{-1} for up to a one year period (Haff, 1999, Hespel, 2001, Jacobs, 1999, Plisk & Kreider, 1999). It is possible that the co-ingestion of other substances (for example, too much sugar) with creatine may account for nausea, diarrhea or vomiting. The individual may have irritations if the creatine loading is occurring during exercise (ACSM, 2000). Gastrointestinal problems can also be attributed to having too much undissolved creatine in the solution (Haff, 1997).

Long term creatine monohydrate supplementation (up to 5 years) did not impair renal function in healthy athletes (ACSM, 2000). No evidence has been found in controlled studies that creatine supplementation causes muscle cramps or strains in healthy participants or those with neuromuscular disease (ASCM, 2000). It is important to remind individuals ingesting creatine that adequate amounts of water and electrolytes are needed during activity. It is dehydration and decreased amount of minerals that is the most common cause of muscle cramps. It is very difficult to replete water and electrolyte stores in the body if unrealistic work conditions are inflicted for days (Plisk & Kreider, 1999).

A positive side effect of creatine monohydrate supplementation is a greater amount of muscle mass, which can increase an individual's basal metabolism. This may play a role in body fat reduction and/or maintenance when combined with an exercise regime (Plisk & Kreider, 1999).

2.9 Creatine and exercise

It has been found that creatine supplementation can significantly improve strength, the number of repetitions completed through repeat set protocols, and can increase the volume of resistance training (Volek et al., 1999, Tarnopolsky et al., 2001, Kilduff et al., 2002, Kelly et al., 1998). The greatest improvements during exercise while supplementing with creatine have been found in repetitive high power output exercise bout series (the third, fourth or fifth sets) while using short rest periods (60-120 sec) (Haff, 1999, Lemon, 2002). Weightlifters and/or bodybuilders may especially benefit from creatine supplementation. If phosphocreatine levels are increased and maintained for an extended period, the individual should be able to train at higher intensities for longer lengths of time, which, in turn, should promote a better training response (Volek & Kraemer, 1996).

2.10 Strength measures and the menstrual cycle

There have been concerns expressed regarding the influence of the female menstrual cycle and performance variables with various types of exercise. According to Shephard (2000), there is strong agreement in the literature that physical performance shows very little change over the course of a normal menstrual cycle. Performance measures requiring strength may even show a slight improvement during the premenstrual phase. The participant's cycle should have little impact on the overall scores of her strength measures.

2.11 Research in the area of females and creatine supplementation

There has been very little research done in the area of creatine supplementation in females. The majority of studies have used healthy male subjects

between the ages of 18 and 35. It has been found that females can significantly increase muscular strength when supplementing with creatine and concurrently exercise training, over various periods of time (Brenner et al., 2000, Larson-Meyer et al., 2000, Vandenberghe et al., 1997). Creatine seems to increase muscle mass more so in males than females (Lemon, 2002), and it is hypothesized that this attenuated increase in body mass in women is perhaps due to less initial muscle mass in comparison to their male counterparts (ACSM, 2000, Vandenberghe et al., 1997). Forsberg et al., (1991) also discovered that females tend to have a higher average total creatine content in skeletal muscle than men, which could result in less creatine uptake during periods of supplementation. The literature regarding this area is scarce and needs to be enhanced to enable researchers to construct recommendations to the female population that can be based on accurate data.

2.12 Creatine intake and creatinine excretion

There are direct techniques that are used to determine creatine and creatinine levels within skeletal muscle. Such techniques include muscle biopsy, nuclear magnetic resonance (NMR) or magnetic resonance imaging or spectroscopy, such as P-MRS. One indirect technique involves the measurement of urine creatine content, with the presumption being that the remainder of the oral supplement has been retained by skeletal muscle. Because some research has shown that oral creatine ingestion may markedly decrease urinary volume during the initial days of supplementation, presumably due to an increase of intracellular water retention, measurement of urine volume has been used as an indirect marker of increased intramuscular creatine content (Williams et al, 1999).

Urinanalysis is a non-invasive, effective way to determine the amount of creatinine and creatine present in the urine and represents a measure of the physiological environment of an individual's body. The quantity of creatinine and creatine present in the urine can be used to estimate the amount of creatine retained and utilized based on a given dosage (Burke et al., 2001). Skeletal muscle is the main source of urinary creatinine (greater than 80%) (Wang et al, 1996), and therefore creatinine levels will vary as a function of muscle mass, being on average less in females than male subjects (ACSM, 2000).

2.13 DEXA

The use of dual energy x-ray absorptiometry (DEXA) as a tool to assess body composition changes has become increasingly popular in recent years. A couple of notable advantages regarding DEXA is that a whole-body scan can be completed in less than 20 minutes for the average adult or child and radiation dosages are quite low (<1 mrem) (Pietrobelli et al., 1998). Most DEXA systems with appropriate software packages are capable of estimating regional and whole-body bone mineral, fat, and fat-free soft tissues (Heymsfield et al., 1997). Accuracy of DEXA fat and bone mineral estimates in animals and humans, varying widely in body size, are highly correlated with corresponding criterion estimates, such as chemical analysis of cadavers and IVNA (in vivo neutron activation analysis) (Heymsfield et al., 1997).

It is possible to reduce the measurement error substantially by using approaches based on three-compartment models which combine measurements of body water or bone mineral with measurements of body density. Although they are more accurate than equations based on two-compartment models, these equations

assume a constant mineral-to-protein or protein-to-water ratio. DEXA has two important advantages over traditional two-compartment models. First, DEXA measurements are based on a three-compartment model and simultaneously gives an estimate of fat, fat-free soft tissue (ie., lean tissue mass) and bone. Lean soft tissue (LST) is comprised of minerals, glycogen, proteins and water, while soft tissue is based on the components of LST plus fat. Total body weight includes LST, soft tissue and bone minerals. Secondly, this method provides estimates of regional body composition and total body composition so that limb and trunk fat can be independently estimated (Lohman & Going, 1998).

Body composition estimates using DEXA are usually highly reproducible, with repeated measurements over one day in the same subject demonstrating coefficient of variance of about 1% for total body bone mineral, 2% for fat-free soft tissue, and 0.8% for fat (Heymsfield et al., 1997). Chilibeck et al., (1994) found that whole-body bone mass and body composition measurements and most lean mass and subregion bone mineral density measurements are precise enough to detect changes (approximately 2%) expected after interventions such as exercise training using female subjects. Therefore, DEXA measurements should determine even small changes after 9.5 weeks of resistance training in the female participants that will be examined.

The DEXA machine used in this study has reported coefficient of variations (CV) of 1.6±0.3 for percent fat, a CV of 1.5±192 grams of fat, a CV of 0.6±271 grams of lean tissue, and a bone mineral density of 0.5±0.006 g/cm^2 (Wilkinson & McCargar, 2004).

2.14 Summary of Literature Review

In summary, it is evident that there is a lack of studies involving female participants who have supplemented with creatine monohydrate while concurrently resistance training. Also, more sensitive body composition assessment measures, such as DEXA, need to be used in order to address small changes in body composition that may occur over a period of time. This study has helped to contribute to the literature regarding creatine supplementation, and has allowed researchers to come to a better understanding of how females respond to creatine supplementation while resistance training.

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CHAPTER 3

Effects of Creatine Monohydrate Supplementation on Body Composition and Strength Indices in Experienced Resistance Trained Females

3.1 Introduction

Creatine monohydrate (Cr) supplementation has been shown to increase total creatine content in skeletal muscle (Hultman, 1995, Clark, 1997), enhance performance in high-intensity, intermittent exercise (Volek & Kraemer, 1996, Casey et al., 1996, Preen et al., 2001, Kirskey et al., 1999, Jones et al., 1999) and resistance training (Volek et al., 1999, Tarnopolsky et al., 2001, Kilduff et al., 2002, Kelly et al., 1998, Vandenberghe et al., 1997, Larson-Meyer et al., 2000, Brenner et al., 2000). In particular, this popular over-the-counter nutritional supplement, when used in conjunction with resistance training, has become the supplement of choice for athletes and fitness enthusiasts who wish to increase muscle mass and overall body strength. One of the main mechanisms cited for the ergogenic effects of creatine on muscle mass and strength improvements is the individual trainee's ability to work at higher intensities for an extended period of time, which would result in a better training response (Volek & Kraemer, 1996).

The majority of the published literature on creatine monohydrate and its impact on muscle hypertrophy, strength and power gains has been based primarily on studies using young male participants in the experimental design (Volek et al., 1999, Bemben et al., 2001, Earnest et al., 1994, Kelly et al., 1998, Kilduff et al., 2002, Peeters et al., 1999, Pearson et al., 1999, Stone et al., 1999, Vukovich & Michaelis, 1998). There have been concerns expressed that the results of these male-based

studies may not be generalizable to similar female populations. To the best of the investigator's knowledge, there have been only three peer reviewed studies that have used female participants to investigate the effects of longer-term creatine supplementation on muscle strength and body composition (Brenner et al., 2000, Larson-Meyer et al., 2000, Vandenberghe et al., 1997) while others have looked at acute supplementation protocols and other physiological variables (Cox et al., 2002, Hamilton et al., 2000, Ledford et al., 1999, Stout et al., 2000). Considering the limited research that has utilized a female subject pool and the vast range of testing protocols, there is a need for further study on the effects of creatine supplementation and concurrent resistance training on body composition and strength measures in females. Therefore the purpose of this study was to measure body composition changes and strength indices in experienced recreational female weight lifters who combined 9.5-weeks of resistance training with creatine monohydrate supplementation. Based on the majority of previously published research using both male and female participants, it was hypothesized that the female participants who ingested creatine monohydrate along with an intensive resistance training program would have greater increases in muscle mass and strength measures than those receiving a placebo while using the same resistance training program. Secondly, it was also hypothesized that those participants supplementing with creatine monohydrate would be able to maintain a greater load or volume of work during the 9.5 weeks of training than those using a placebo.

3.2 Participants

Thirty females (18-35 years) from the University of Alberta and Edmonton area were recruited to participate in the study. Criteria for participation included a minimum of one year of regular resistance training experience (approximately 2-3 days per week), no use of any nutritional supplement 6 weeks prior to the study, and maintenance of a balanced, mixed diet (Appendix A). Each subject was initially screened for exercise risk by completing a PAR-Q questionnaire (Appendix B). Each participant was asked to fill out a pre-screening questionnaire that asked specific lifestyle questions, in order to ensure they met the requirements of the study (Appendix C). Every participant received detailed information regarding the study at the orientation meeting that occurred at the beginning of September 2003 (Appendix D). All training procedures, testing protocols and associated risks for the 9.5-week period were outlined. Every participant signed an informed consent in accordance with the University of Alberta guidelines for research with human subjects (Appendix E). All procedures were approved by the University of Alberta's Ethics Review Committee for use of human subjects in research (Appendix F).

3.3 Research Design

The study was conducted over a 9.5-week period using a two group matched, double blind, randomly assigned design that was placebo controlled (Fig. 1 in Appendix G). At the initiation of the study, there were 30 participants in total, but over the course of the research, 4 participants left (one had a gastrointestinal reaction to the supplement, one dislocated her patella while jogging, and two left because of time commitment), leaving 26 participants in total. One group (n= 13) received a

creatine monohydrate supplement for the duration of the 9.5 weeks, while the control group (n=13) received a placebo treatment that looked and tasted similar to the creatine supplement. All participants were matched on their combined bench press and incline leg press 1RM strength pre-test scores divided by their lean body mass and then randomly assigned to either the creatine monohydrate (Cr) group or the placebo (Pl) group. Prior to the random placement, all baseline measures were performed, including a DEXA procedure for body composition and upper and lower body strength measures (1 RM strength test and a 70% 1 RM, 5 set repeat protocol for the bench press and incline leg press) (Appendix H for information on DEXA and Appendix I for 1 RM and 70% 1 RM procedures). Baseline values of combined bench press and incline leg press 1 RM strength divided by lean body mass were calculated for each participant and used for ranking the subjects from highest to lowest scores. Once ranking of the participants occurred, the subjects were then divided into half (1 to 15, and 16 to 30). The top half were randomly assigned to one of the groups followed by the bottom half. Once the participants were assigned to the creatine monohydrate or placebo group, the 9.5-week resistance training program was initiated. The most important variables that were assessed in the study were body composition (total body mass, fat free body mass, fat mass, and body fat percentage), and changes in muscular strength with a 1 RM and the 5-set repeat protocol using 70% of 1RM (for bench press and incline leg press exercises). These variables were assessed at baseline and at the completion of the 9.5-week of resistance training program. All body composition and strength measures were tested within 48 hours of completion of the resistance training program. Strength measures were also repeated

at the midpoint of the study (5 weeks) to determine when the most significant strength changes occurred during the course of time.

3.4 Resistance Training Program

A whole body resistance training program was performed by the participants at their fitness facility, which may or may not have been located at the University of Alberta's Fitness and Lifestyle Centre. All participants had an initial training orientation to ensure that all lifting techniques were performed correctly and uniformly between individuals. Each training session began with a cardiovascular warm up on a piece of cardio equipment of the subject's choice for approximately 5-10 minutes, followed by static stretching of the muscle groups that were exercised that day. All participants performed identical 4-day per week split routines. Days 1 and 3 consisted of bench press, latissimus pull downs, military press (dumbbell), seated row (machine or seated), incline bench press, upright row (dumbbell, barbell or cable), bicep curls (dumbbell or barbell) and tricep extensions (rope or bent bar) exercises which concentrated on the chest, back and arm muscle groups. Days 2 and 4 consisted of Smith machine squats, incline leg press, lunges, hamstring curls, abdominal crunches, reverse curls, and oblique crunches which focused on the legs and abdominal area (Appendix J for example of training log). Days 1 and 2 were performed on Mondays and Tuesdays, while days 3 and 4 were performed Thursdays and Fridays. Wednesdays, Saturdays and Sundays were normally rest days where no form of resistance training was performed. Recreational activities that the participant may have already been involved in were permitted to continue throughout the duration of the study (for example, soccer league twice a week). All exercise

intensities were progressively increased using a repetition goal method over the duration of the study to maximize the training effect. The 2-for-2 rule (if the participant could perform two or more repetitions over their assigned repetition goal in the last set in two consecutive workouts for a certain exercise, then additional load was added to that exercise at the next exercise session) was applied for this progressive increase in the resistance training load. It was expected that all participants complied with the outlined training program; additional resistance training exercises were not permitted. It was strongly recommended that each participant use a spotter for certain exercises (ie., bench press and incline bench press) in order to reach their actual maximal failure on each set.

During the first and second training weeks, participants performed 3 sets of 10 to 12 repetitions for each exercise. Each participant selected a predetermined load that allowed her to fail between the 10th and 12th repetition. Throughout weeks 3 to 5, participants performed 4 sets of 10 to 12 repetitions for each exercise. During weeks 6 to 8, 4 sets of 8 to 10 repetitions were completed, while the 8th to 10th week utilized a 6 to 8 repetition failure for all exercises during 5 sets. Over the duration of the 9.5 weeks, load was adjusted as necessary in order for each individual to fail at the pre-selected repetitions. A sub-maximal warm-up set was recommended for each participant to complete before beginning the working sets, and was not included as part of the sets outlined in the training log. Each participant was issued a training log during the 9.5 week period to record all sets, repetitions, loads and exercises completed. Additional space was provided to record any potential side effects the participant may have attributed to the creatine supplementation. On each training

day, the workout sheet was signed by the fitness facility employee that was on shift in order to maximize compliance to exercise sessions. Although each workout session was not supervised, the researcher had contact with each participant once weekly during the supplement pick-up in order to answer any questions or concerns regarding the study. Also the participants handed in their training logs on a weekly basis in order for feedback to be given in terms of the amount of volume being completed in accordance to previous workouts. The weekly training log interaction was also used to calculate training volume of each of the experimental groups for bench press, incline leg press and squat exercises.

3.5 Supplementation Protocol

The creatine monohydrate group received 0.3g $CrM \cdot kg^{-1} \cdot d^{-1}$ (Creapure™ Creatine Monohydrate, Allmax Nutrition, Toronto, Ontario) (see Appendix K) for seven days (Williams et al., 1999, ACSM, 2000, Haff, 1999, Hultman, 1995, Plisk & Kreider, 1999, Wyss, 2000) which was the acute loading phase, while the placebo group received the same amount of polycose placebo (Shopper's Drug Mart, Edmonton, AB) during the seven day period. For the remaining 58 day maintenance phase, participants in the Cr group were supplemented with 0.03g $CrM \cdot kg^{-1} \cdot d^{-1}$ (Williams et al., 1999, Haff, 1999, Hultman, 1995), while the Pl group received the same amount of polycose. Approximately 100g of simple sugar (no name®, 100 cal, 24 g CHO, 0 g fat, 0 g protein, per 250 mL) was dissolved in each litre of water with the creatine supplement in order to facilitate creatine uptake into skeletal muscle (Green et al., 1996, Robinson et al., 1999). All supplements were pre-measured, pre-packaged and distributed on a weekly basis to each participant using a double blind

protocol. Participants received specific instructions on how to prepare and ingest the supplement prior to the supplementation stage. During the acute loading phase, supplements were taken four times per day, (8 A.M., 12 P.M., 4 P.M., and 8 P.M.). All participants were asked to refrain from caffeine during the seven day acute loading phase, and informed that creatine was not to be ingested simultaneously with caffeine during the remaining 58 day maintenance phase. Simultaneous caffeine ingestion has been shown to counteract any ergogenic effects creatine may have on skeletal muscle (Vandenberghe et al., 1996). During the maintenance phase participants ingested the supplement once daily with approximately 25g of simple sugar dissolved in every 250mL of water.

At the completion of the study, each participant was given a short survey questioning them on any side effects they may have experienced while they were ingesting the supplement, and to also determine which group they believed they were assigned (Appendix L).

3.6 Body Composition

Pre and post body composition measures were assessed with the use of DEXA (Lunar Prodigy machine, Madison, WI). The same qualified technician from the Faculty of Agriculture, Forestry and Home Economics performed all pre and post DEXA body composition measures. All female participants were asked to provide a urine sample in order to administer a pregnancy test (Stanbio QuStick™ hCG Pregnancy Test, Stanbio Laboratory, Boerne, Texas) prior to the DEXA to verify they were not pregnant, since pregnancy is the major exclusion criteria for having a scan. If a participant was found to be pregnant, they refrained from the having the scan

done and were excluded from the study. Other exclusion criteria included individuals who had recently undergone a nuclear medicine scan or barium swallow within the last 3 weeks prior to the DEXA scan.

The participant was required to change into a hospital gown and lay supine on a table. The scan took approximately 5 minutes. The DEXA printouts provided specific data such as bone mineral content, bone mineral density, lean tissue mass in specific areas of the body (i.e. left arm, left trunk, left leg, right arm, right trunk, right leg), fat mass in these areas, body fat percentage and total body mass (Appendix M). Participants were not informed of any body composition variables (excluding weight) until the study was completed.

3.7 Strength measures

Strength measures were performed at baseline, at the mid point of the study (5 weeks) and post supplementation (9.5 weeks) at the University of Alberta Varsity gym. An attempt was made to control diurnal variation and circadian rhythms by ensuring each participant repeated their strength measures within one hour of the original strength test and all measures were repeated on the same day of the week (Lemon, 2002, Tarnopolsky & MacLennan, 2000).

All participants were asked to refrain from any type of strenuous exercise 36 hours before the testing period, and were not to consume any caffeine products 4 hours prior to strength testing. Participants warmed up on a cycle ergometer for approximately 5 minutes, followed by static stretching that focused on the chest and legs. All participants were educated on the criteria needed to perform one complete repetition for the bench press and incline leg press to ensure all participants were

aware of correct technique. Participants performed ten repetitions at a self-selected weight to warm up the specific muscles needed for the particular exercise, and critiqued on technique by the tester. Participants selected a load that they felt confident they could repeat 3 times and then performed the set. Participants attempted a 1-RM with a pre-selected load. This step was repeated until the true 1-RM was completed. A 2.5 minute rest was given between each attempt to ensure adequate recovery of the ATP-PC system. Hand placement on the lifting bar was selected by calculating 200% of biacromial breadth of each participant (Clemons & Aaron, 1997). This was noted on the pre-test score sheet to standardize biomechanical factors that effect the bench press exercise. The participant had to maintain 5-point contact (head, shoulders, back, buttocks and feet) throughout the entire lift. A lift-off was utilized to ensure the participant was performing only one repetition. The participant had to lower the bar to the chest, pause momentarily, and then press it vertically until the elbows were fully extended.

To assess the incline leg press strength, participants had to have proper foot placement, which was on a standardized black line on the lifting plate with feet shoulder width apart. A 90˚ knee flexion had to be performed for a complete repetition on the incline leg press. Participants lifted the plate and brought the weight down until knees reached 90˚, which was confirmed with a goniometer. From here, the distance in centimeters (a ruler on the side on the incline leg press) was marked on the leg press and the distance was recorded on the data sheet. This process allowed for uniformity of knee angle for each test, since this can affect the amount of weight lifted. It also permitted the tester and the participant to identify when the pre-

determined distance had been reached in order to accomplish one repetition. The same protocol was repeated for the leg incline press as the bench press in terms of repetitions and rest periods. A maximum number of 5 sets were used to reach 1 RM measures. All strength testers had considerable experience in assessing 1 RM strength measures and were informed on the exact protocol of each test to ensure consistency between testers. The 1 RM bench press and incline leg press were randomly assessed, meaning order was not a factor for the participants.

48 hours after the 1 RM testing for the bench press and incline leg press had been completed, a 5 set repeat protocol was elicited. During this procedure, 70% of the participant's 1 RM was selected (Earnest et al., 1995) with participants completing as many repetitions as possible to failure five times, with 75 seconds of rest between each set (Lemon, 2002). The same warm-up and stretching protocol was followed, along with hand and foot placement being identical to what was established in the 1 RM testing procedure. During the mid (5 week) and post study 70% 1 RM testing, participants were asked to perform their initial 70% 1 RM, 5 set protocol on the training day of the respective workout. For example, they performed their initial (pre-study load) 70% 1 RM bench press test as their first exercise on Monday, when they were training upper body. During the actual testing day, their new 1 RM test score (from mid-study and post-study tests) was used to calculate the 70% load. By having the participant execute their own 70% 1RM, the initial and the new 70% 1 RM would not have to be completed in the same day, preventing fatigue from being an influencing factor on the latter score.

In conjunction with this performance study, a second researcher conducted an assessment of exercise psychology variables that the participants experienced. This consisted of a pre-, mid-study and post-test psychological survey that were given after the participants had completed the DEXA scan. A follow-up questionnaire was also given 5 weeks post completion of the study.

3.8 Dietary analysis

Dietary analysis was performed in order to determine daily energy intake and macronutrient content, specifically looking at meat intake, since the only source of exogenous creatine is through the diet. Three-day dietary logs were recorded at baseline and at the end of the 9.5 week training/supplementation period (Appendix N). Each dietary record included a weekend day (ie. Sunday, Monday, Tuesday). Prior to the initiation of the study, procedures of how to record food intake into the dietary log was explained to all the participants and examples were given. Intervention was utilized after the first log was completed in terms of specificity of recording food and measurements. Participants were encouraged to include any nutritional analyses from the food packaging in their logs to increase accuracy. Each dietary record was analyzed using a nutritional software program (Food Processor, ESHA, Research, Salem, OR).

3.9 Urinary analysis

The 24-hour urine samples were collected and analyzed prior to supplementation, after the 7-day acute loading phase, at the 5 week period (mid-study), and at the end of the 9.5-week training/supplementation phase in order to indirectly measure creatine levels in skeletal muscle (Burke et al., 2001). Each

participant was given a 4 L urine collection bottle and instructed on the proper collection procedure. The 24-hour period began with the collection of the second urination of the specified day and all subsequent urinations, including the first urination of the following day (Burke et al., 2001). The volume of urine was measured, and then two samples of each urine sample were aliquotted into tubes and frozen at -80°C until further assessment. All concentrations of excreted creatine and creatinine were analyzed in duplicate via enzymatic spectrophotometer assays (Milton-Roy Spectronic 601, Ivyland, Pennsylvania, USA) (see Appendix O for assay procedure) (Bernt & Bergmeyer, 1974). The intra-assay coefficient of variance (CV) for the creatinine assays were 0.9% while the creatine CV was found to be 0.8%. The quantity of creatine and creatinine present in the urine was used to estimate the amount of creatine retained and utilized based on the subject's given dosage (Burke et al., 2001).

3.10 Training Volumes

The participants training volumes were calculated for the bench press, incline leg press and squat exercises that were performed during the training sessions. This was completed by multiplying the number of repetitions completed, with the load and number of sets performed (repetitions x load x sets).

3.11 Data Analysis

A Cohen's power calculation of 0.798 had been determined for this study, using a r^2 value equal to 0.20 (for a moderate to large effect) and a p value of <0.05 that calculated having 36 participants in order to obtain significant results.

A two-way (group · time) analysis of variance (ANOVA) was used for analysis of all dependent variables (body composition, strength variables, urinary creatine and creatinine). This involved a comparison between groups (creatine supplementation and placebo) over the course of training (repeated measures) using a statistical software program (Statistica Version 6 from Statsoft, Tulsa, OK). Significance was set at an alpha level (p) of 0.05 for all statistical tests. A Newman-Keuls multiple comparison *post-hoc* test was used to determine when significant F ratios occurred. All data were expressed as means ± SD unless otherwise indicated.

3.2.1 Results

3.2.2 Subject characteristics

The Pl and Cr experimental groups had a mean age and height of 23.6±2.2 years and 165.9±3.7 cm and 25.6±4.6 years and 162.3±5.1 cm respectively. There was no significant difference between the Cr and Pl groups for changes in total body weight (kg). The Pl and Cr experimental groups had a mean pre-post body mass of 65.4±8.7 kg and 65.7±13.4 kg and 65.4±7.7 kg and 66.7±13.8 kg, respectively (see Fig 1). Fifteen participants were ingesting an oral contraceptive pill during the course of the study, 2 were on Depovera, and 9 participants were not on any form of oral contraceptive.

3.2.3 DEXA Results

There was a significant training effect for both groups in total lean body mass (g) over the course of the study. The Pl group increased lean body mass (g) from

43,826±4,852.5g pre study to 44,752±4,694.5g post study. The Cr group also increased in lean body mass from 42,804±4,153.4 g pre- study to 43,882±4,003 g post- study (p value = 0.000) (see Fig 2). Both groups decreased their body fat percentage significantly, but no significant difference was found in terms of actual grams of fat. Percent fat decreased with the placebo group from pre- study, 29.5±8.6 % to 28.1±8.9 % post- study while the Cr group went from a fat % of 30.9±8.0 to 30.2±7.8 % (p value = 0.012) (see Fig 3). There was no significant difference found between groups for lean body mass (g) for the arms or the legs. There was a training effect for both groups when lean mass (g) in the trunk was considered, which increased over the period of the study. The Pl group increased trunk muscle mass from 20,902±3,135 g pre study to 21,671±2,920.6 g post study. The Cr group increased trunk muscle mass from 20,287±2,552 g pre study to 20,992±2,567.2 g post study (p value = 0.000) (see Table 1). Bone mineral density (BMD) for the placebo group increased by 0.001g/cm^2 over the period of the study, while the Cr group increased BMD by 0.048g/cm^2.

3.2.4 Strength measures

There was a training effect for both groups over time for the bench press. The Pl group increased 1 RM bench strength from 42.1±5.7 kg pre- study, to 45.9±6.0 kg mid- study, to 49.3±6.3 kg post-study while the Cr group increased from 41.4±9.6 kg pre- study, to 44.8±9.2 kg mid- study, to 48.8±10.6 kg post- study (p value = 0.000) (Figure 4). The same significant trend occurred for the 1 RM incline leg press. The placebo group pressed 175.7±54.6 kg pre- study, to 220.6±59.9kg mid- study, to 239.9±52.0 kg post- study while the Cr group increased from 167.3±52.6 kg, to

212.6±56.8 kg mid- study, to 239.0±56.6 kg post- study (p value = 0.000) (Figure 5). No interaction effects were observed between the Cr and Pl groups.

When comparing total number of repetitions completed over the 5 sets for pre study, mid-study and post study 70% 1 RM bench press, there was a significant training effect (p value = 0.009) in both groups during mid week and post study testing. The Pl group performed 42.7±12.0 repetitions pre study, 48.8±7.7 repetitions mid-study and 47.9±7.0 repetitions post-study. The Cr group performed 45.0±7.5 repetitions pre-study, 51.3±8.3 repetitions mid-study and 51.1±7.8 repetitions post-study (see Fig 6). See Figures 8, 9 and 10 for the number of repetitions performed for each set pre, mid and post study. There was no significant difference found for the total number of repetitions performed over the 5 sets pre-, mid, and post study for the incline leg press (Figure 7). Figures 11, 12 and 13 contain the number of repetitions performed for each set pre-, mid-, and post study for the Pl and Cr groups for the incline leg press.

There was a significant increase in bench press strength (kg) for both groups when total load was divided by arms and trunk body mass (g) total. The Pl group increased relative BP strength (kg) from 1.6±0.2 kg pre-study to 1.8±0.3 kg post-study. The Cr group increased relative BP strength (kg) from 1.7±0.3 kg pre-study to 1.9±0.3 kg post-study (p value = 0.000) (see Fig 14). The same held true for relative BP strength (kg) divided by total lean body mass. The Pl group increased their BP strength divided by total lean body mass from 1.0 kg±0.1 kg pre-study to 1.1±0.2 kg post-study. The Cr group increased from 1.0±0.2 kg pre-study to 1.1±0.2 kg post-study (p value = 0.000) (see Fig 15). A significant increase was also found for relative

ILP (kg) when total load was divided by legs and trunk mass total or with total lean body mass. The Pl group increased from 4.9±1.3 kg pre-study to 6.6±1.2 kg post-study. The Cr group increased from 4.6±1.3 kg pre-study to 6.6±1.2 kg post-study (p value = 0.000) (see Fig 16). When looking at relative ILP (kg) by total lean body mass (kg), a significant difference was found for both groups as well. The Pl group went from 4.0±1.1 kg pre-study to 5.4±1.0 kg post-study while the Cr group increased from 4.0±1.0 kg pre-study to 5.4±1.1 kg post-study (p value = 0.000) (see Fig 17).

3.2.5 Dietary Results

There was a main effect for time with the groups for total caloric intake. It seemed that the Pl group decreased their caloric intake from pre to post experiment while the Cr group increased their caloric intake. The Pl group went from ingesting 1904.2±248.9 calories (cal) per day pre- study to 1701.4±256.9 cal post- study. The Cr group ingested 1721.8±252.0 cal per day pre- study, and increased caloric intake post- study to 1910.1±454.3 cal (p value = 0.011) (see Fig 18). There was no significant difference found in protein, carbohydrate, or fat intake (all expressed as a percent). Although not statistically significant, the average water intake over the 3 day period for the placebo group decreased from 2912.1±1159.5 mL pre- study to 2515.1±1169.4 mL post- study while the Cr group increased daily average water intake from 2644.1±1063.0 mL pre- study to 2928.5±809.3 mL post-study.

3.2.6 Urinary analysis

There was a significant interaction effect between the Cr and Pl group for creatine urine levels (mmol/24 hours) at post load and mid study parameters. The Pl

group had baseline levels of 2.0±1.0 mmol/24hr, post 7 day loading phase levels of 1.6±0.9 mmol/24hr, mid study (5 weeks) levels of 2.3±1.9 mmol/24 hr and post study (9.5 weeks) levels of creatine at 1.5±0.7 mmol/24 hr. The Cr group had pre-study levels of creatine of 2.8±2.2 mmol/24 hr, levels of 40.2±35.5 mmol/24 hr at the post 7 day loading phase, 17.6±9.8 mmol/24 hr levels at mid study (5 weeks) and 4.1±3.2 mmol/24 hr post study (p value = 0.000) (see Fig 19). No effect was found between groups for creatinine urine levels (mmol/24 hours). The Pl group pre study levels were 12.7±4.1 mmol/24 hr, the post loading phase was 12.2±4.2 mmol/24 hr, mid study levels were 13.3±2.6 mmol/24 hr, and post study levels were 12.6±4.1 mmol/24 hr. The Cr group experienced pre-study levels of 11.8±2.2 mmol/ 24 hr, post loading levels of 15.6±6.9 mmol/24 hr, mid-study levels of 15.4±3.6 mmol/24 hr and post-study levels of 12.7±3.5 mmol/24 hr (see Fig 20).

3.2.7 Training volumes

A significant main effect for time was found in training volumes for the bench press, squat and incline leg press over the 9.5 week period for both groups (all 3 having a p value of 0.000). No interaction between experimental groups was found (Figures 21, 22 and 23).

3.3.1 Discussion

The aim of the present study was to determine the effects of creatine monohydrate supplementation on body composition and strength indices in young, experienced, resistance trained females. It was hypothesized that those individuals that ingested creatine monohydrate while concurrently resistance training would have

greater increases in strength measures and muscle mass than those who were receiving the placebo supplement and resistance training. It was also hypothesized that the participants taking the creatine supplement would be able to perform a greater amount of work in terms of volume during the 9.5 weeks of resistance training than those who were ingesting the placebo.

Three main findings emerged from this study:

1. The 9.5 week resistance training program improved strength measures significantly for both groups in terms of bench press and incline leg press strength.
2. Both Pl and Cr experimental groups increased lean body mass and trunk mass significantly over the training period.
3. Creatine supplementation did not allow for greater volumes of training to be achieved compared to the placebo over a 9.5 week resistance training period.

Both the Cr and Pl groups achieved similar results from the 9.5 week resistance training program. Both significantly increased total lean body and lean trunk mass while decreasing the percentage of body fat. Strength measures significantly improved over the course of the study for both groups for the 1 RM bench press and incline leg press, indicating the Cr supplementation did not provide an ergogenic effect while performing a concurrent resistance training program than over the same training program alone. When looking at 1 RM changes that occurred in terms of a percent increase, the Pl group had a 17% increase, while the Cr group had an 18% increase in BP strength from pre- to post- study. The Pl group increased their 1 RM ILP measures by 37%, while the Cr group increased by 43% from pre- to post- study.

In terms of relative body strength, significant differences were also found when dividing strength by the corresponding body parts. When dividing bench press strength (kg) by the amount of lean tissue in the arms and trunk, a significant difference was found over time for both groups. The same result occurred when dividing bench press strength with total lean body mass. Similar responses occurred with the incline leg press strength. When incline leg press strength (kg) was divided by the amount of lean tissue in the legs and trunk, a significant difference was found pre- and post- study. The same result occurred when dividing incline leg press strength with total lean body mass.

When comparing this study to the results of other studies using female participants (Vandenberghe et al., 1997, Larson-Meyer et al., 2000, Brenner et al., 2000, Cox et al., 2002, Hamilton et al., 2000, Ledford et al., 1999, Stout et al., 2000) with a creatine supplementation protocol, this was the only one to use a relative supplementation dosage based on body weight ($0.3 g \cdot kg \cdot d^{-1}$ for the 7 day loading phase and $0.03 g \cdot kg \cdot d^{-1}$ for the maintenance phase). Previous studies that used the more common absolute dosages of 20 to 30 $g/kg/d^{-1}$ may not have met supplementation requirements of individuals with higher than normal lean or total body mass. With a range of the body mass in the present study of 49.5 kg to 108.2 kg, participants at the higher range may not have received a sufficient dose of creatine if an absolute dose regime was implemented.

The present study was the only other study to use DEXA as a method of body composition assessment (Larson-Meyer et al., 2000 was the other) when addressing female participants. Other studies (Vandenberghe et al., 1997, Brenner et al., 2000,

Hamilton et al., 2000) used hydrodensitometry or anthropometric measures to assess changes in body composition. Hydrodensitometry can no longer be considered as a true 'gold standard'. Since nearly all indirect methods of predicting percent body fat are based on this method as a criterion measure, the validity of such methods is limited (Foss & Keteyian, 1998). Anthropometric measures are also an indirect method that has limited accuracy except when used with participants who are similar to the original group studied to develop the predictive method. Different predictive protocols can yield widely differing results on the same participant (Foss & Keteyian, 1998).

Chilibeck et al., (1994) found that whole-body bone mass and body composition measurements and most lean mass and subregion bone mineral density measurements are precise enough to detect changes (approximately 2%) expected after interventions such as exercise training using female subjects when using DEXA. Anthropometric measures and hydrodensitometry do not reveal detailed information about changes that may occur in lean mass tissue throughout various regions of the body.

The present study used the largest experimental sample (26) in comparison to those studies that have used strictly females. The next highest number was 24 subjects (Hamilton et al., 2000) but this study was a short-term (7 days) experiment that did not have any strength measures. According to Tarnopolsky & Maclennan (2000) and Plisk & Kreider (1999), a minimum number of 15 participants per group should be used in order to minimize the amount of Type II error during statistical analysis. Unfortunately, the present study only had 13 participants per group

(originally it was 15) therefore the statistical power was decreased when analyzing the data.

Other than Vandenberghe et al. (1997), the present study is the only other study to use a form of measuring urinary creatine and creatinine levels in females. No other studies involving females used any form of direct or indirect method to measure creatine uptake within the muscle. By analyzing the creatine levels found within the participants urine, it can be determined that a loading effect did occur within the Cr group, however, the Cr group did not appear to gain any benefits or ergogenic boost from it. It is reasonable to believe that although a loading of creatine monohydrate did occur within the skeletal muscle, it may not have been a sufficient amount in order to see a performance enhancing effect in relation to the strength scores performed. Greenhaff (1994) has suggested that an increase of approximately 20 mmol/kg dm of creatine in the muscle may be necessary in order for an individual to see a "response" or ergogenic effect from creatine monohydrate supplementation. Since urinary creatine analysis cannot determine this specific information, it is not known if these numbers were reached in the individuals ingesting creatine and therefore, may be a potential reason as to why no significant differences were achieved in the creatine group over the placebo group over 9.5 weeks of resistance training.

It appears that the studies using strictly female participants vary in the means of using carbohydrates to enhance creatine uptake within the muscle. Although many studies have been published that support the concept of ingesting carbohydrate and creatine simultaneously (ACSM, 2000, Haff, 1999, Nelson, 2001, Green, 1996a,

1996b) some studies (Brenner et al., 2000, Hamilton et al., 2000, Vandenberghe et al., 1997) and perhaps Cox et al. (2002), did not mention any use of carbohydrate supplementation in order to augment creatine uptake. Nelson (2001) stated that in order to reduce inter-subject variability in response to creatine supplementation, carbohydrates should be ingested simultaneously. The present study ensured that carbohydrate (in the form of juice powder) was included with the creatine supplement in order for the participant to ingest both of the supplements simultaneously. Even though this precaution was taken, it did not guarantee that a greater uptake of creatine would be demonstrated within skeletal muscle. As previously mentioned, an increase of approximately 20 mmol/kg of creatine within the muscle may be warranted in order to determine any type of ergogenic response to creatine monohydrate, and the methods used in this study could not assess this.

The present study also ensured that no vegetarians were included in order to reduce the variation in pre-existing creatine levels within skeletal muscle. Since vegetarians usually have lower creatine levels within skeletal muscle (because of no exogenous ingestion), they seem to respond best to creatine supplementation. Harris et al. (1992), found that the effect of creatine supplementation was greatest in those participants with the lowest initial total creatine contents. In order to reduce the variability, a pre-existing condition that allowed an individual to be included in the present study was that meat had to be ingested on a weekly basis. It is possible that the ingestion of meat and fish products may have possibly blunted or attenuated the uptake of creatine into the muscle during the loading period. Since the literature has documented that large increases in intracellular creatine can be obtained by

vegetarians through a proper supplementation protocol, it seems reasonable that those subjects who ingest a mixed diet that includes meat and fish products, may reduce the uptake of creatine monohydrate into the muscle cell using a similar supplementation schedule. Further research is needed in order to warrant this suggestion.

For optimal protein synthesis, diet must supply sufficient carbohydrate or fat calories for ATP production. When it does not, dietary and tissue proteins are used for energy. Eating large amounts of protein does not significantly increase body tissue protein – the only way to increase muscle mass is to place extra demands on the skeletal muscle by resistance exercise (Marieb, 1998). General recommendations regarding protein intake for the average person is approximately 0.8grams of protein per kilogram of body weight. A greater range of protein intake is recommended for athletes, or those engaged in higher levels of physical activity, ranging between 1.5 to 2.0 g of protein per kg of body weight (Baechle & Earle, 2000). The Pl participants in this group had a pre-study protein intake of 1.39g/kg body weight while the Cr group had an intake of 1.07 g/kg body weight. Post-study the Pl participants decreased their protein intake to 1.29g/kg body weight, while the Cr group increased their protein intake to 1.33g/kg of body weight. These numbers do exceed the recommended guidelines for the average population, but are just shy of the recommended intakes for those who are more physically active.

The best way to determine whether an athlete is consuming adequate calories is to monitor body weight. The Pl group's total body weight actually remained the same throughout the study (65.4 kg pre and post) while the Cr participants increased their total body weight from 65.7kg pre study to 66.7 kg post study. Although

participants in both groups seemed to have reported relatively low caloric intakes throughout the study, (between 1700 and 1910 kcal per day on average); their body weight did not significantly increase or decrease over the duration of the study. It could be hypothesized that the recording of the participant's diet was more than likely underestimated pre and post study. Baechle and Earle (2000) have reported a method of estimating daily caloric intake based on levels of physical activity. Participants in this study would fall under a "heavy" physical activity category (such as resistance training) and which suggests females to ingest 44kcal per kilogram of body weight. Since the Pl group had a mean body weight pre and post study of 65.4 kg, this would indicate that the participants would need to ingest 2877.6 kcal per day – this is nearly a 1000 kcal difference. The Cr participants, on average, would have needed to ingest approximately 2912.8 kcal per day based on a body weight of 66.2 kg. It seems quite probable that the dietary intake records were not recorded properly since body weight either stayed consistent or increased slightly.

Whether athletes can gain muscle and lose body fat simultaneously depends primarily on their level of training. Previously untrained subjects can both decrease body fat and gain lean body mass as a result of caloric restriction and training; however, it is unlikely that trained athletes who already possess a relatively low body fat percent could achieve body mass reduction without losing some lean body mass. Gradual weight loss ensures maximum fat loss and preservation of lean tissue (Baechle & Earle, 2000).

Several studies have suggested that creatine supplementation could benefit athletes over a long term period by enabling a higher training load which would

provide a greater stimulus for accelerating muscle hypertrophy and strength (Greenhaff, 1997, Vandenberghe et al., 1997, Volek et al., 1999). However, the secondary hypothesis that those ingesting creatine should be able to perform more work in terms of training volume, than those ingesting the placebo was refuted. The ingestion of creatine monohydrate while concurrently resistance training did not prove to increase the amount of volume completed by the participants. Those ingesting the placebo while concurrently resistance training did just as much work in terms of training volume as those ingesting the creatine. Again, this may have occurred because the participants ingesting the creatine supplement may not have had a considerable enhancement in the mean increase in muscle creatine stores in order for a significant difference to be elicited during statistical analysis.

An additional reason as to why an increase in training volume did not occur could be due to the fact that the training sessions were unsupervised. Participants may not have been training as hard as they potentially could have, and by not going to failure on each set, the training volumes may not have changed enough to demonstrate statistical significance. The training volume data may have been more accurate if all training sessions were supervised, but unfortunately for this study, it was not possible. Mazzetti et al. (2000) found that when two identical 12 week resistance training programs were performed by participants with 1-2 years of resistance training experience (similar to the subject pool used in the present study), that the group that was directly supervised resulted in a greater rate of training load increase and magnitude over the 12-week period than those who were unsupervised. This point should be taken into consideration when planning future research. To

date, this is the only study involving female participants that has attempted to calculate training volumes; that the researcher is aware of.

Although self-reporting was used to calculate training volumes, it is important to note that to the knowledge of the investigator, other experimental designs have failed to report increases in training loads by creatine supplemented groups (Syrotuik et al., 2001, Volek et al., 1999). This research acknowledges the limitations of self-reported data that is not supervised during its collection, and thus views these results with some hesitation. There may have been an increase in training volume that occurred over the 9.5 week training period that the self-reporting was unable to detect.

When looking at the number of repetitions performed during the 5 set 70% 1 RM repeat protocols, some observations can be made. It was hypothesized that the creatine group would be able to perform more repetitions in the third, fourth or fifth sets, than the participants in the placebo group. At the completion of the study, the statistics did not support this hypothesis. These findings support the work of Syrotuik et al. (2000) who determined that no advantage took place when comparing the creatine group to the placebo group while examining total lifting volume with 80% of a 1RM bench press protocol to failure. Volek et al. (1999) also found no difference in total lifting volume of 80% of 1RM bench press after 10 or 12 weeks of resistance training, although, they did cite significant improvements in jump squat peak power on set 4 in those subjects ingesting creatine after 12 weeks of resistance training. Earnest et al. (1994) also cited that total lifting volume was significantly higher in the group receiving creatine when a 70% 1 RM protocol was implemented. The studies

mentioned above (excluding the jump squat data) used only one set to failure to determine total lifting volume. Since one of the proposed mechanisms of creatine supplementation is a higher initial level of free creatine which could help re-synthesize more cellular phosphocreatine during recovery between sets of high intensity work, it is not surprising that the single set protocols did not detect a significant increase in training volume.

It was determined that there was no significance between groups for the 70% 1 RM 5 set repeat protocols for bench and incline leg press. Many of the participants in the study were able to complete a significant amount of repetitions during the first two or three sets (some completing between 40 and 60 repetitions for the leg press). The amount of time it took to perform these extensive amounts of repetitions may have been too lengthy to represent the critical time period that phosphocreatine plays in the energy used to perform the task. By shortening the recovery period from 75 to perhaps 60 seconds, a greater stress would be placed on the ATP-PC system by not allowing it to fully recover before the next set commenced. If creatine stores did increase in skeletal muscle with supplementation, then the pools within the muscle would allow those individuals supplementing to regenerate the phosphocreatine pools faster, thus showing an ability to perform a greater number of repetitions, especially during the latter sets, similar to what has been reported in other research. For future reference, it would be advisable to increase the percent of the 1 RM (perhaps from 70 to 80 or 85% of 1 RM) to help identify if creatine does indeed allow for more overall work to be completed. No other female studies to date, to the knowledge of the

investigator, incorporated any type of repeat set protocol based on a 1 RM strength measure(s) which makes the interpretation of the results difficult.

Finally, the type of participant pool used for the present study has differed from all other creatine supplementation studies that have been demonstrated, to date. Vandenberghe et al. (1997) used sedentary females with no resistance training experience, while Larson-Meyer et al. (2000) and Cox et al. (2002) used elite soccer players and Brenner et al. (2000) used lacrosse players. The present study used experienced resistance trained females (having at least one year of resistance training experience of at least 2 to 3 times per week) as a population. This parameter was instilled to try and decrease the variability in strength scores and to minimize any 'learning effect' through motor learning that could potentially occur within the first few weeks of the resistance training program. It would have been optimal to have the participants perform a strict resistance training program for a number of weeks or months before the initiation of the study in order to minimize these extraneous variables, but this could not be warranted. The term 'experienced' is ambiguous and the researcher does acknowledge this as a potential limitation to the present study.

Based on the results of the current study, it appears that creatine supplementation does not have an ergogenic effect on experienced resistance trained female's body composition or strength indices over a 9.5 week period. A periodized resistance training program that emphasizes an incremental increase in volume over time appears to be just as beneficial to increase strength and muscle mass.

3.3.2 Future Research

The present study examined the effects of creatine supplementation on body composition and strength measures during concurrent supplementation and resistance training in experienced resistance trained females. 9.5 weeks of creatine monohydrate supplementation does not appear to significantly improve strength measures or body composition greater than training alone. A few studies have shown that creatine does have an ergogenic effect on maximal strength gains in females (Vandenberghe et al., 1997, Larson-Meyer et al., 2000, Brenner et al., 2000). It is apparent that the findings in these studies are equivocal and further research needs to be completed. Direct muscle measurements of cellular creatine are required with muscle biopsies or MRI scans for more detailed information in regards to creatine monohydrate loading within skeletal muscle. Also, larger sample sizes are needed to increase statistical power since almost all of the female studies to date have less than 20 participants in total. The continuing use of more precise body composition measurements such as DEXA will also help determine minute changes in muscle mass throughout various regions of the body.

Table 1. The effects of creatine monohydrate (Cr) and placebo (Pl) supplementation on body mass, % body fat, lean body mass (g), lean trunk mass (g), lean arm mass (g) and lean leg mass (g) before and after 9.5 weeks of resistance training. Values are means ±standard deviations.

	PLACEBO		CREATINE	
Training	**Pre**	**Post**	**Pre**	**Post**
Body mass (kg)	65.4±8.7	65.4±7.7	65.7±13.8	66.7±13.8
% body fat	29.5±8.6	28.1±8.9*	30.9±8.0	30.2±7.8*
Lean body mass (g)	43,826±4153.4	44,752±4694.5*	42,804±4153.4	43,882±4003.0*
Lean trunk mass (g)	20,902±3135.0	21,671±2920.6*	20,287±2552.0	20,992±2567.2*
Lean arm mass (g)	4,868±506.3	4,973±483.9	4,619±885.2	4,607±1,025
Lean leg mass (g)	14,750±1627.7	14,760±1593.0	14,607±1468.5	14,960±1654.9

Kg = kilogram, g = grams

* Denotes significantly different from pre study, $p<0.05$.

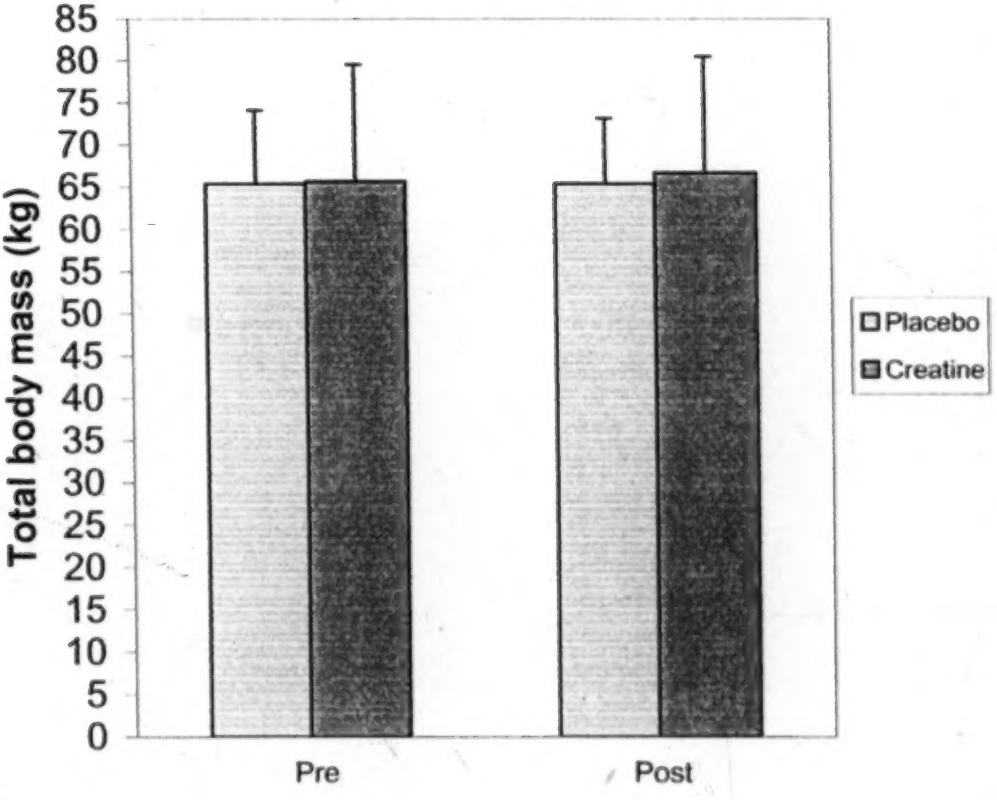

Figure 1: Total body mass (kg) for Pl and Cr groups pre and post study.

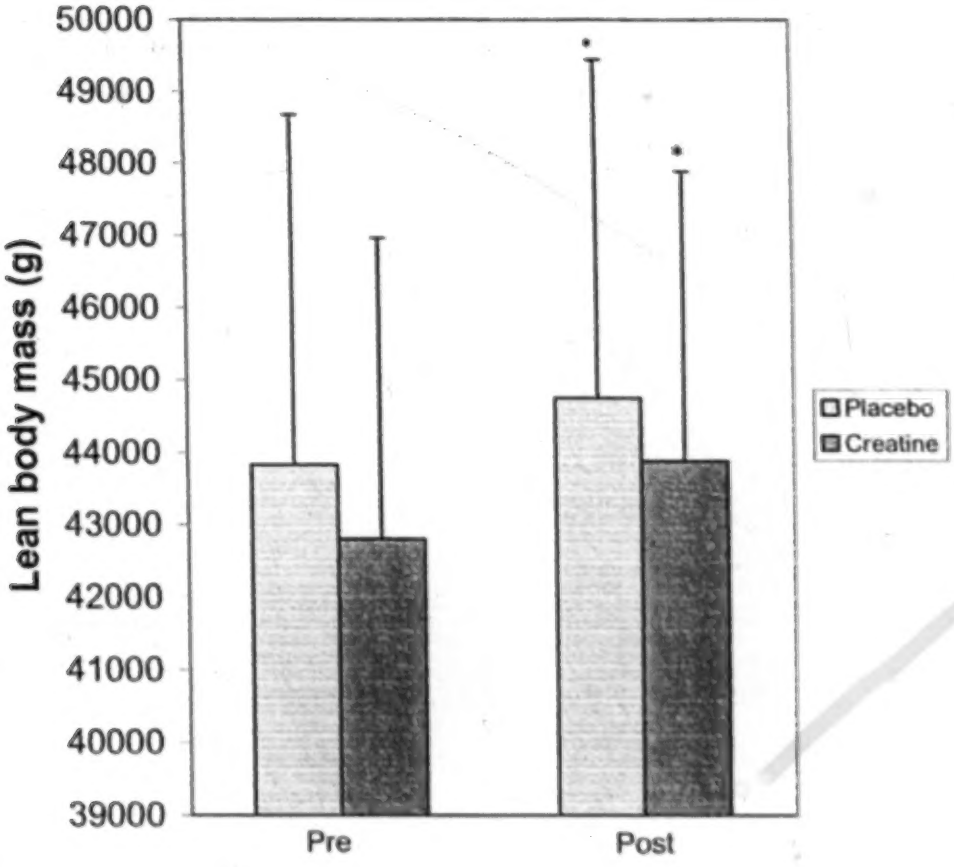

Figure 2: Lean body mass (g) for Pl and Cr groups pre and post study.

* Denotes significantly different from pre study measurements.

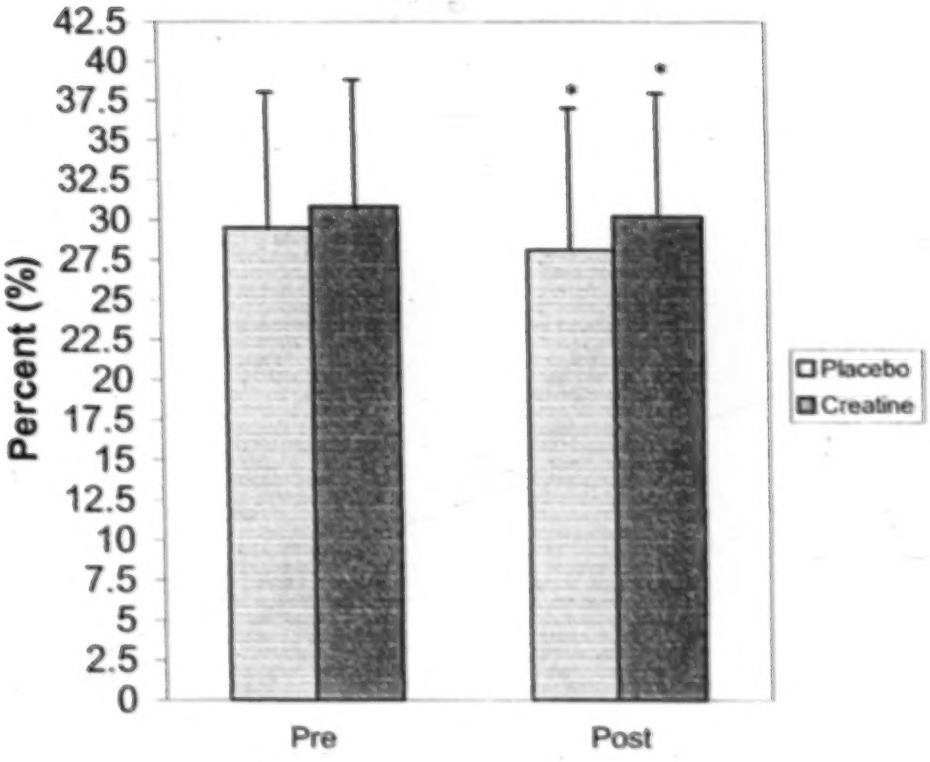

Figure 3: Body fat percent (%) for Pl and Cr groups pre and post study.

*Denotes significantly different from pre study measures.

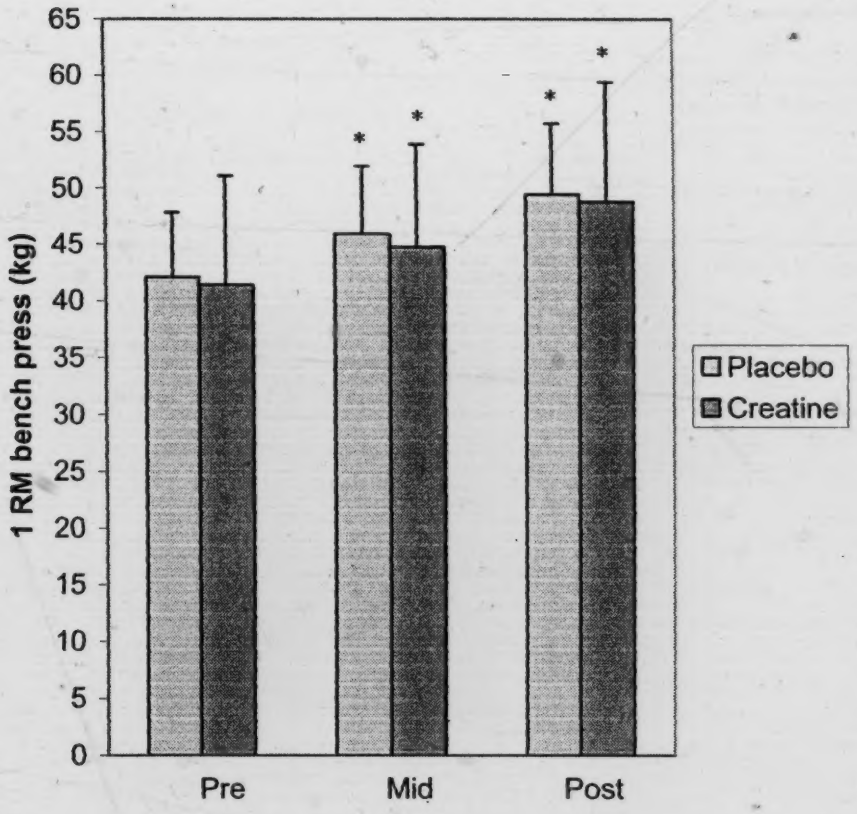

Figure 4: 1 RM BP scores (kg) pre, mid and post study for Pl and Cr groups.

*Denotes significantly different from pre study measures.

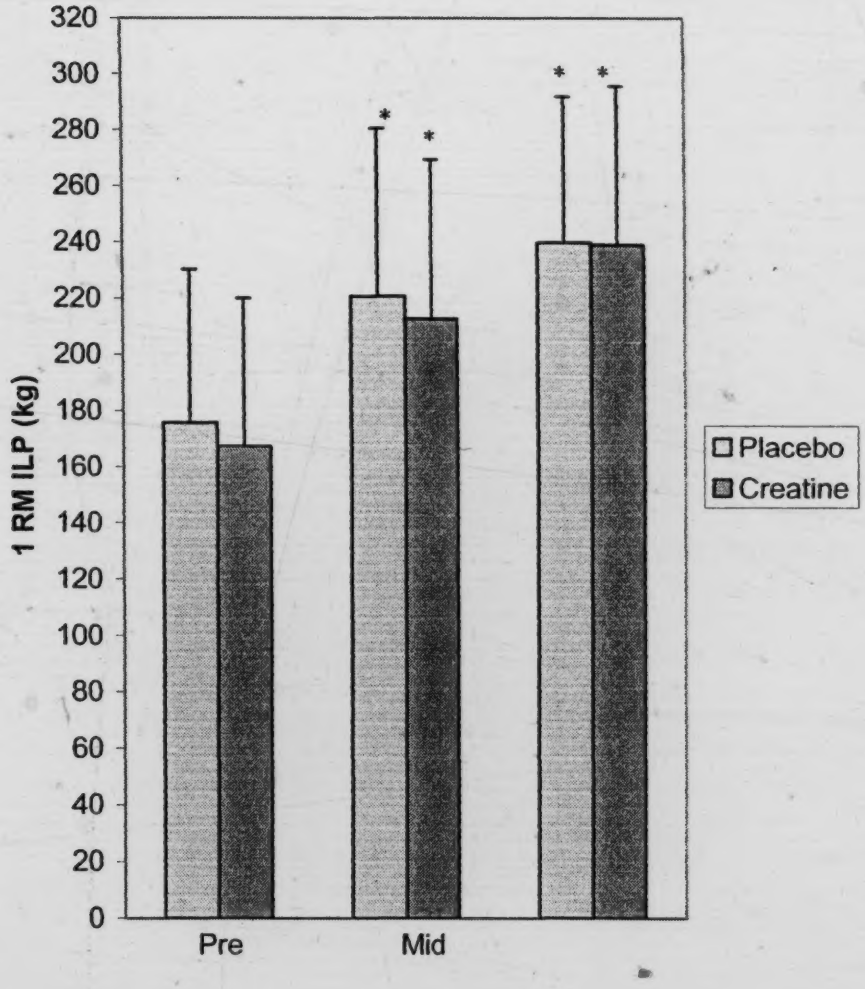

Figure 5. 1 RM ILP scores (kg) for Pl and Cr groups pre, mid, and post study.

*Denotes significantly different from pre study measures.

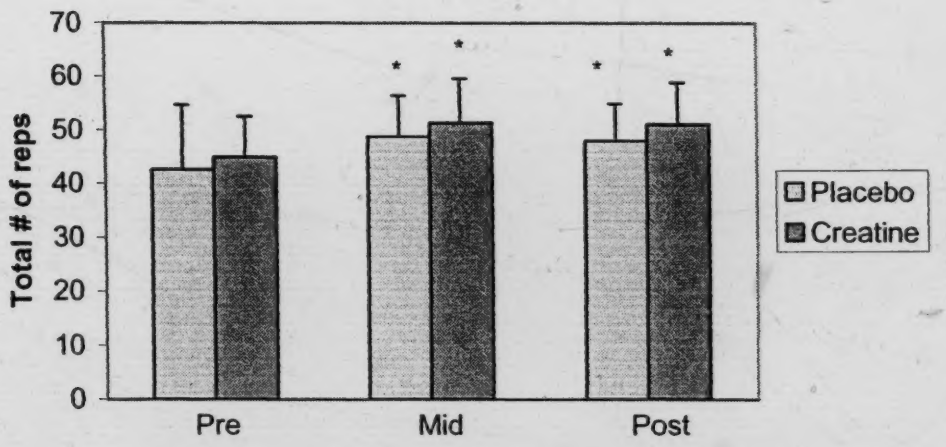

Figure 6. Total number of repetitions completed over 5 sets of 70% 1 RM for BP for the Pl and Cr groups pre, mid and post study.

* Denotes significantly different from pre study measures.

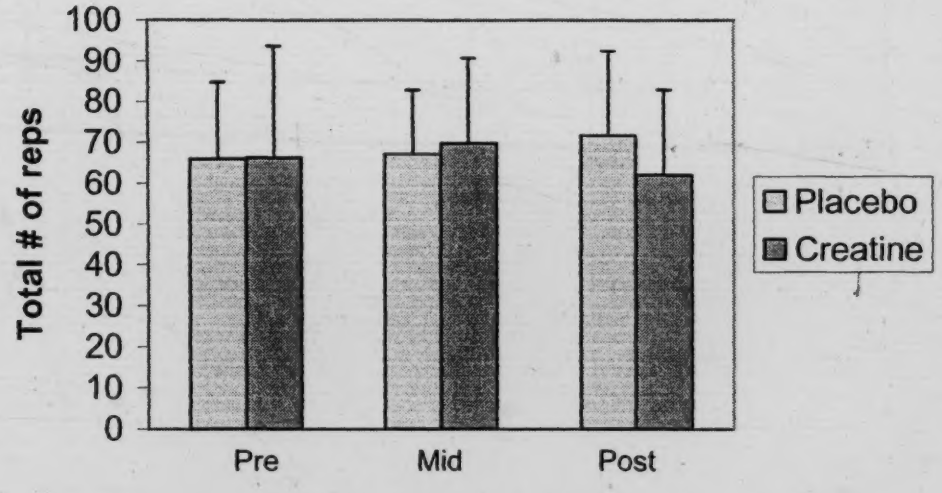

Figure 7. Total number of repetitions completed over 5 sets of 70% 1 RM for the ILP for Pl and Cr groups pre, mid and post study.

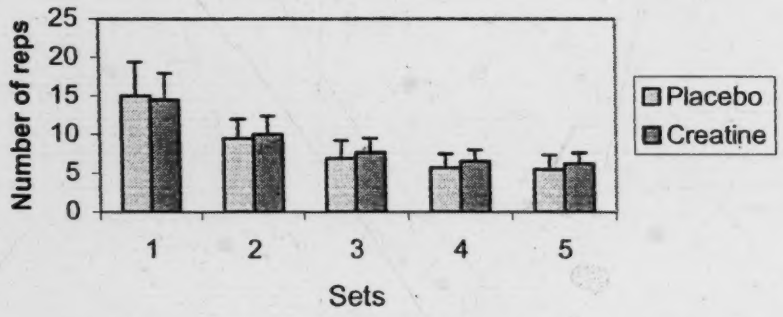

Figure 8. Number of repetitions performed for each set during the 70% 1RM BP protocol during pre study for Pl and Cr groups.

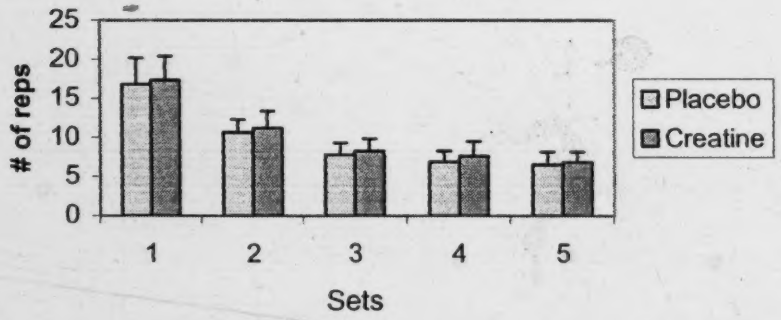

Figure 9. Number of repetitions performed for each set during the 70% 1RM BP protocol during mid study for Pl and Cr groups.

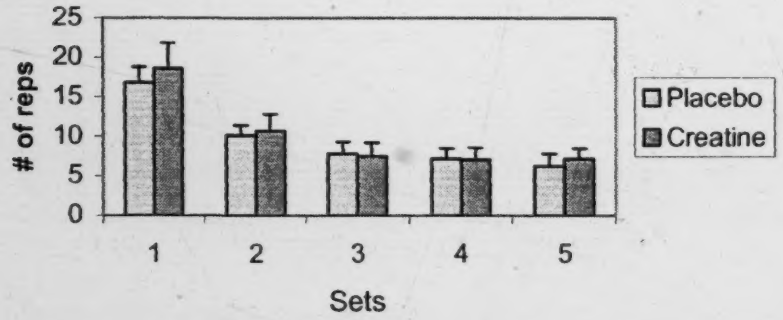

Figure 10. Number of repetitions performed for each set during the 70% 1RM BP protocol during post study for Pl and Cr groups.

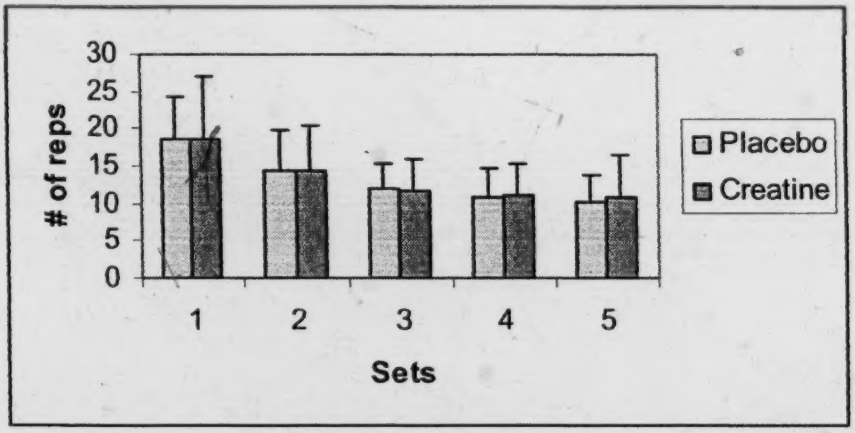

Figure 11. Number of repetitions performed for each set during the 70% 1RM ILP protocol during pre study for Pl and Cr groups.

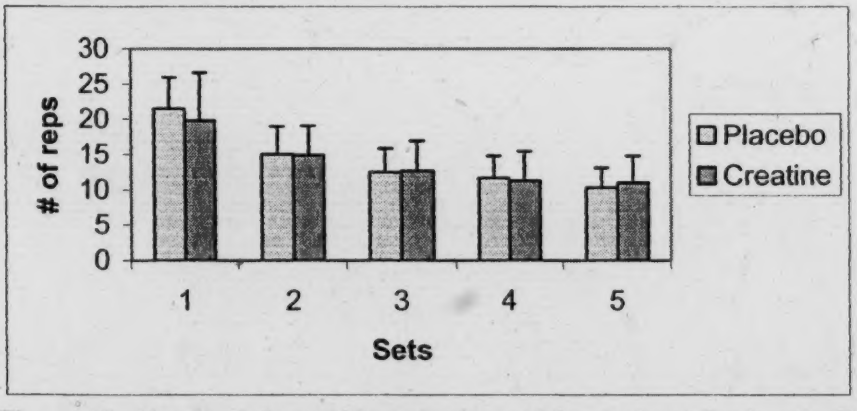

Figure 12. Number of repetitions performed for each set during the 70% 1RM ILP protocol during mid study for Pl and Cr groups.

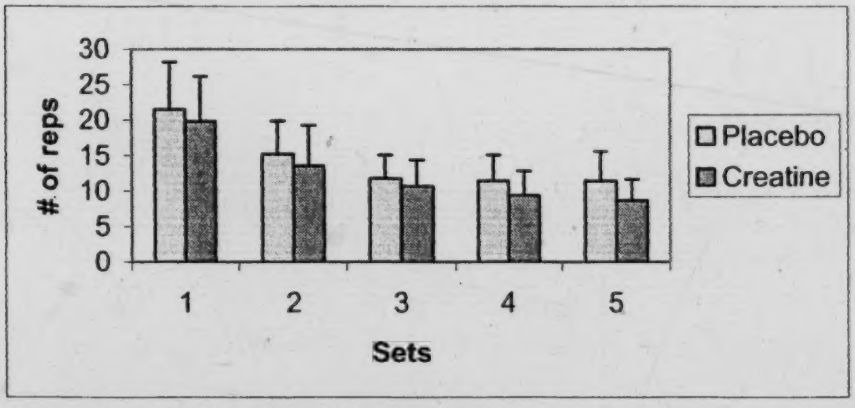

Figure 13. Number of repetitions performed for each set during the 70% 1RM ILP protocol during post study for Pl and Cr groups.

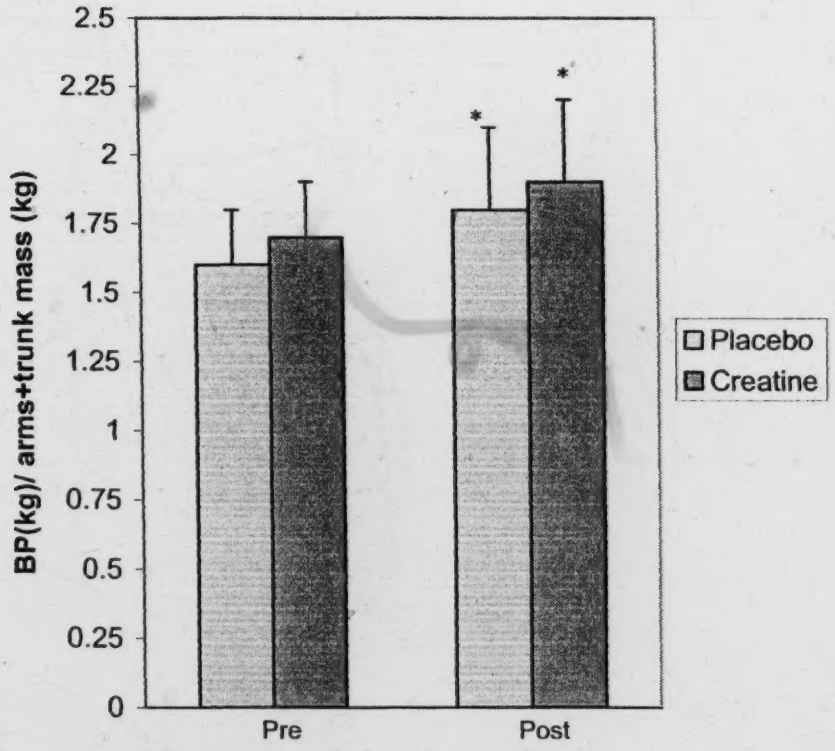

Figure 14. BP load (kg) divided by arms + trunk mass (kg) pre and post study for Pl and Cr groups. Mass based on DEXA results.

*Denotes significantly different from pre study measures.

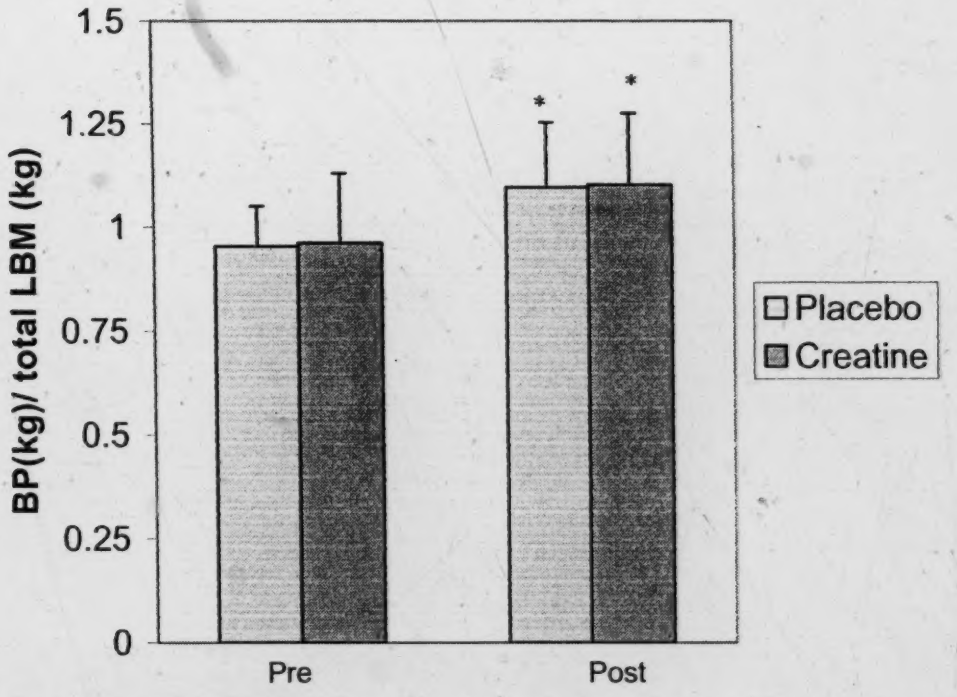

Figure 15. BP load (kg) divided by total LBM (kg) for Pl and Cr groups pre and post study. LBM based on DEXA results.

*Denotes significantly different from pre study measures.

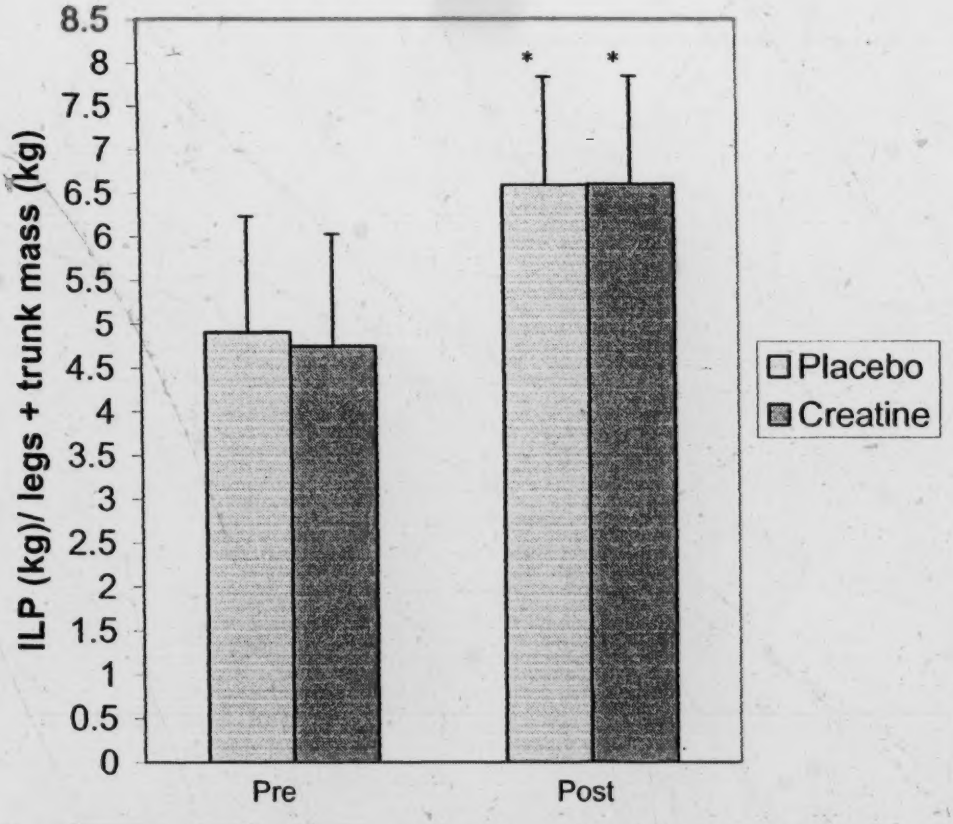

Figure 16. ILP load (kg) divided by legs + trunk mass (kg) as determined by DEXA for Pl and Cr groups pre and post study.

*Denotes significantly different from pre study measures.

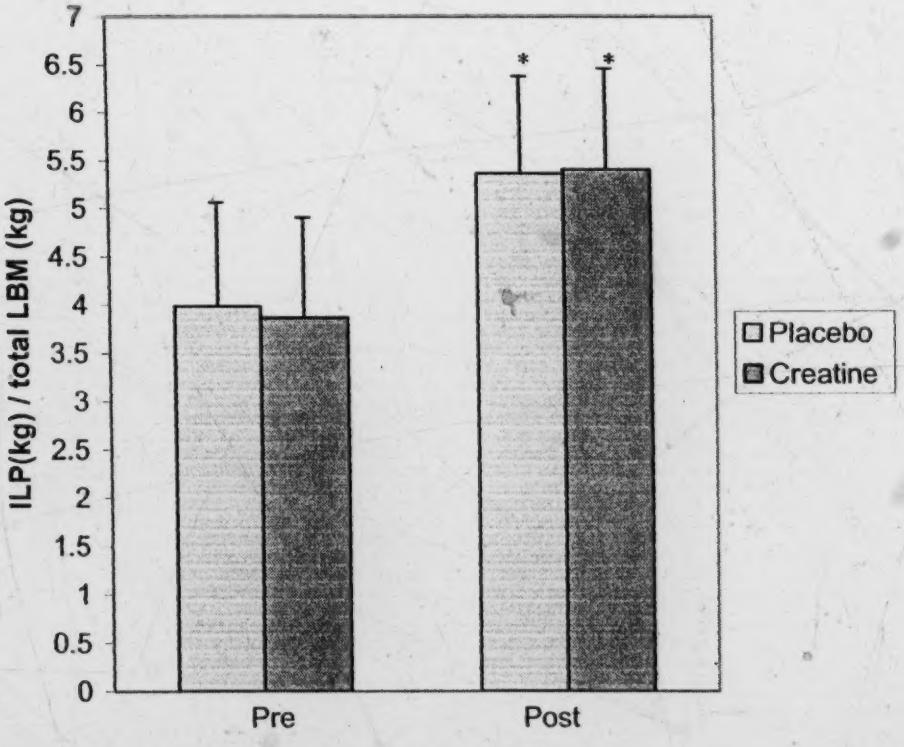

Figure 17. ILP load (kg) divided by total LBM (kg) as determined by DEXA for Pl and Cr groups pre and post study.

* Denotes significantly different from pre study measures.

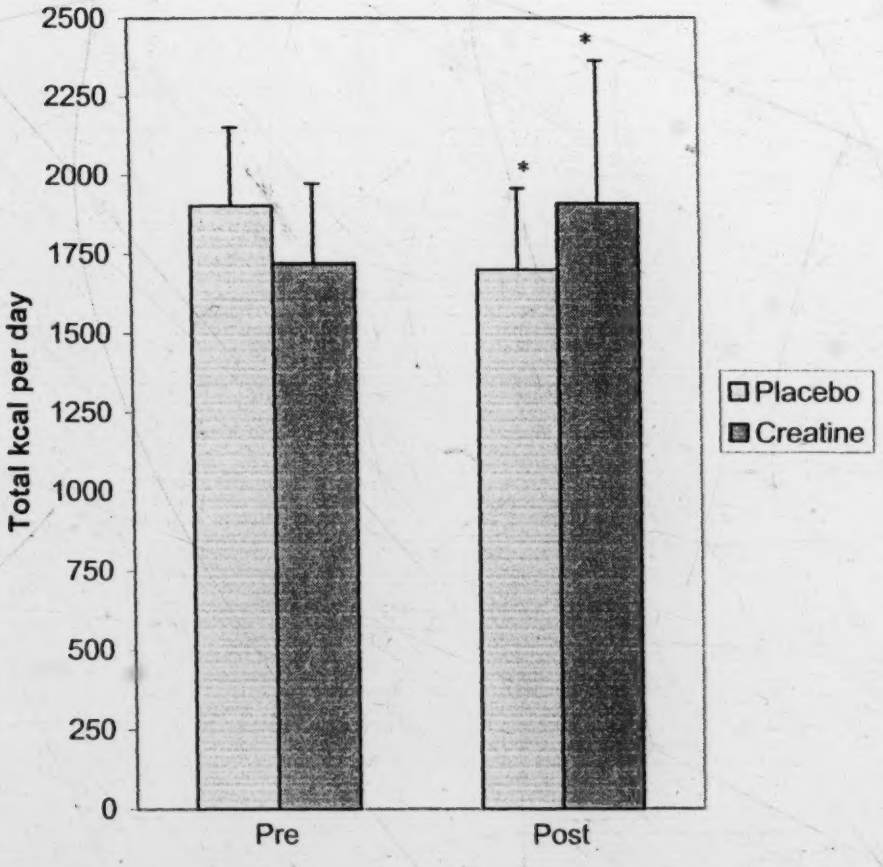

Figure 18. Total calories ingested per day by Pl and Cr groups pre and post study as determined by 3-day dietary logs.

* Denotes significantly different from pre study measures.

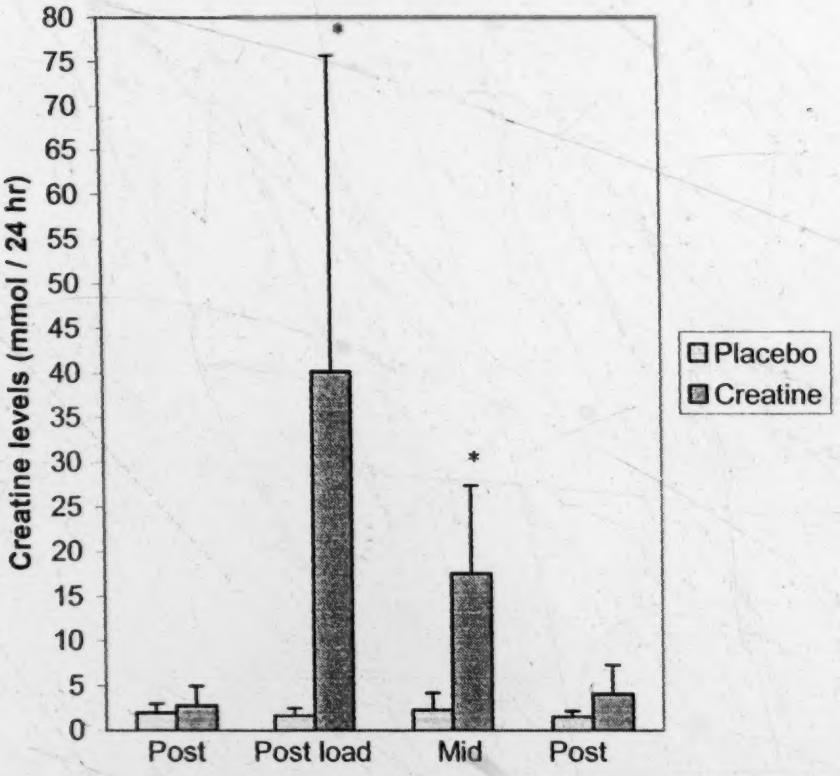

Figure 19. Creatine levels (mmol/24 hr) for Pl and Cr groups pre, post-load, mid and post study.

* Denotes significantly different from pre study measures.

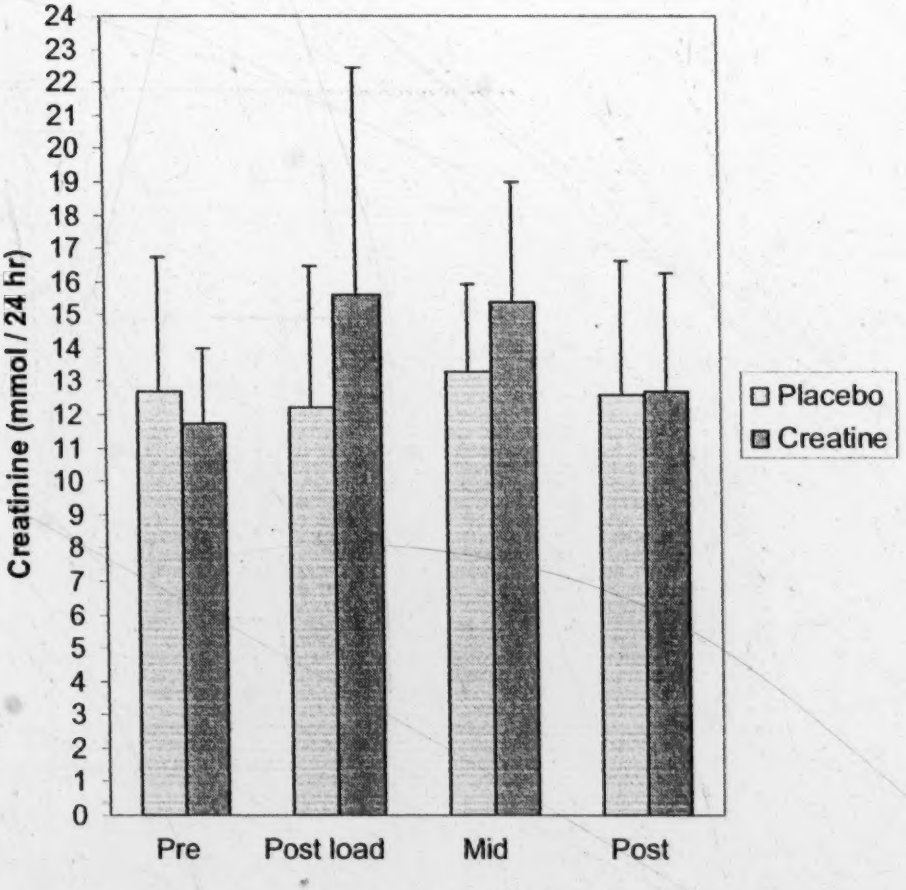

Figure 20. Creatinine levels (mmol/24 hr) for Pl and Cr groups pre, post-load, mid and post study.

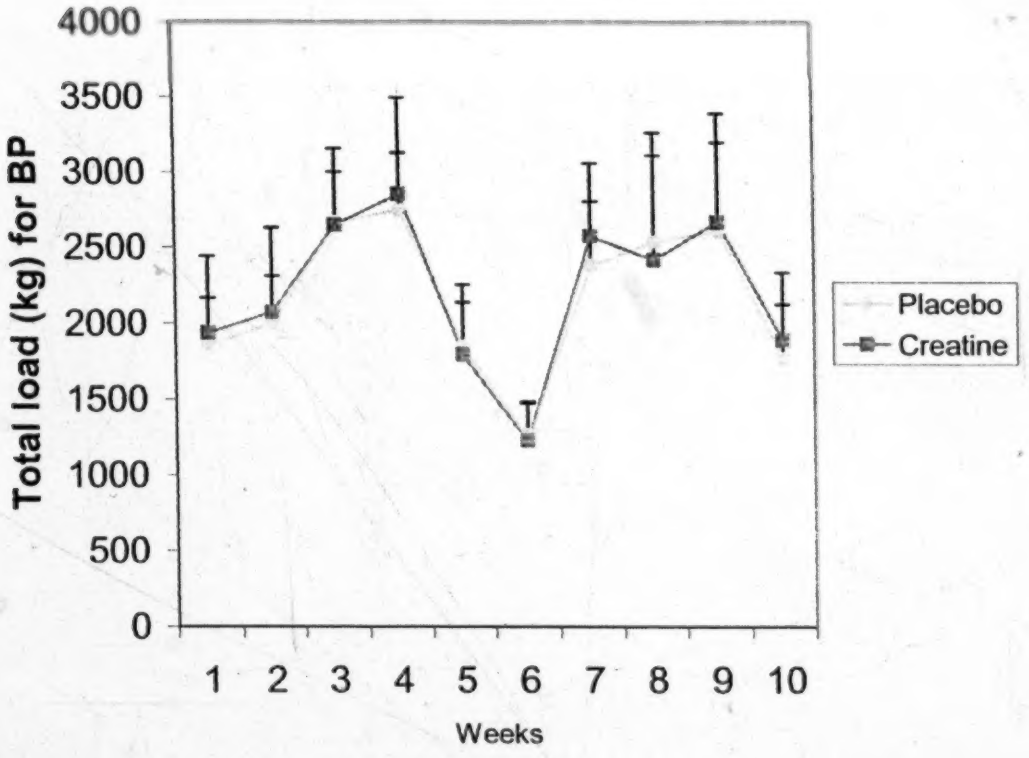

Figure 21. Weekly total load (kg) for BP from weeks 1 through 10 for Pl and Cr groups.

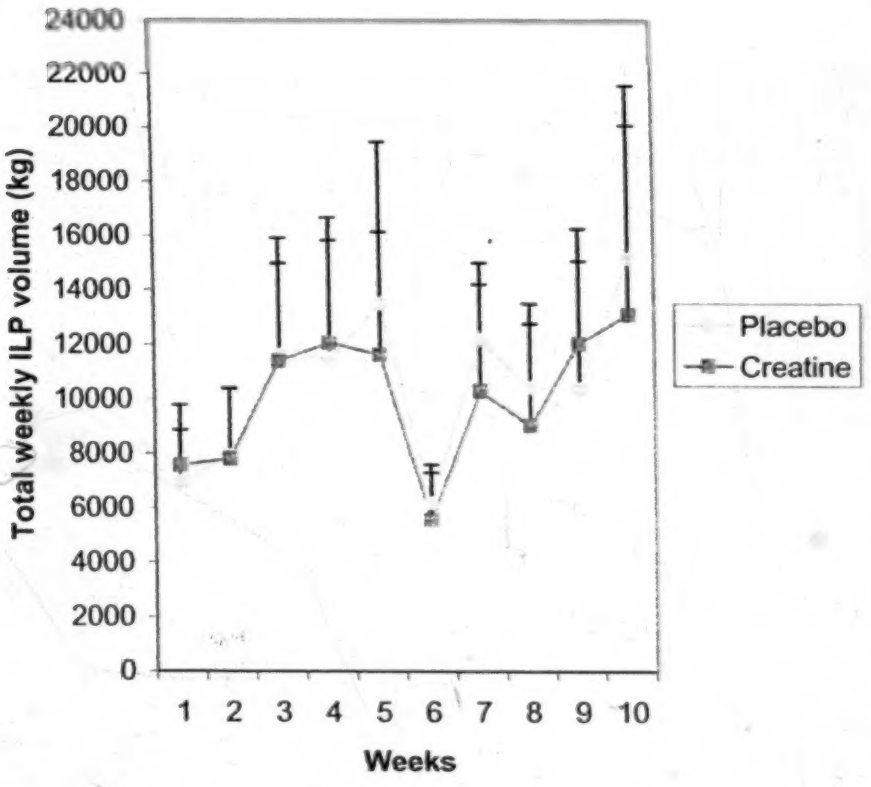

Figure 22. Total weekly volumes for ILP (kg) for Pl and Cr groups over 10 weeks.

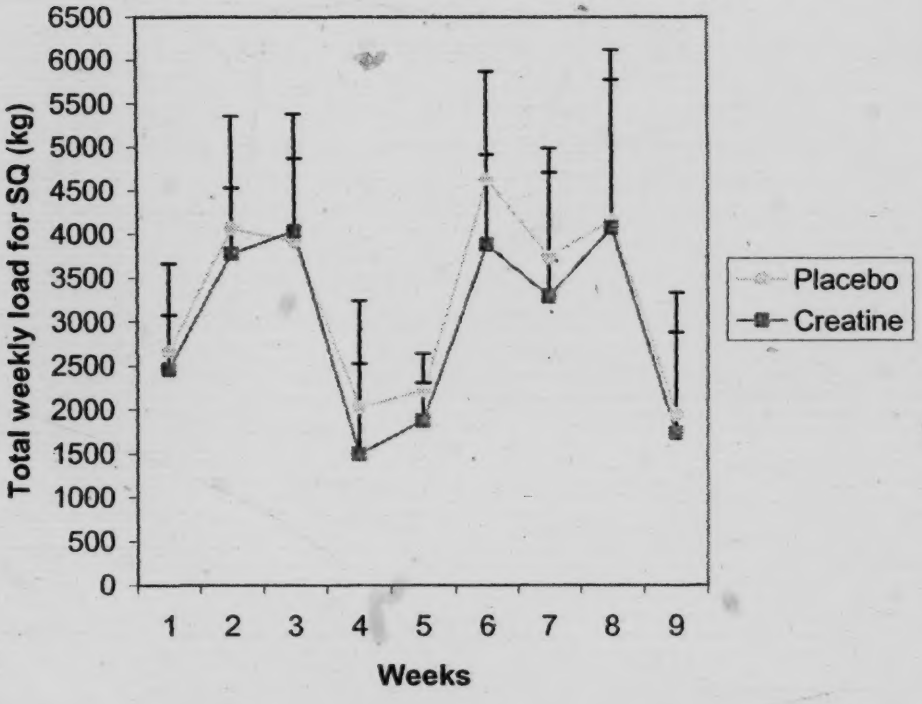

Figure 23. Total weekly load (kg) for squat exercise for Pl and Cr groups for 9 weeks (last workout was not included, since it was only a half week – one workout).

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CHAPTER 4

GENERAL DISCUSSION AND CONCLUSION

4.1 Discussion

The findings from the present study did not support the hypothesis that participants who supplemented with creatine monohydrate while concurrently resistance training would have enhanced strength measures or lean body mass over participants with an identical program, but ingesting a placebo. Furthermore, the results did not show that the participants who supplemented with creatine monohydrate were able to increase their training volume to a greater extent when compared to the placebo group.

Both the creatine and placebo supplementation groups achieved similar results from the resistance training program. Both groups significantly increased their 1 RM bench press and incline leg scores, increased lean body mass and decreased body fat percent after 9.5 weeks of resistance training. The creatine urinary analyses that were performed did indeed show that there was an increase in the amount of creatine monohydrate within the participant's muscle that was ingesting the creatine supplement.

A limitation of the present study was that the training sessions performed over the course of the 9.5 week period were not supervised. If supervision were to occur, creatine monohydrate may have had a greater effect on the amount of training volume being completed during each session. Also, it would have been favorable to have an increased number of participants involved in the study. Tarnopolsky & MacLennan (2000) and Plisk & Kreider (1999) have suggested that in order to elicit a significant

response, a minimum of 15 participants per group be used. The present study began with 15 subjects per group, but over the first few weeks of the study, 4 were unable to continue.

4.2 Practical Applications

The present study did not reveal any physiological reasons to believe that 9.5 weeks of creatine supplementation in conjunction with resistance training enhances body composition or strength indices greater than training alone. The creatine monohydrate group did not demonstrate significantly improved performance in regards to 1 RM strength measures, 70% 1 RM strength measures completed over 5 sets, or increased lean body mass over the placebo group. In terms of training volume, creatine monohydrate did not enable those participants ingesting creatine to perform an increased amount of work, or volume than those supplementing with the placebo. Thus, although the creatine monohydrate supplementation did not appear to enhance performance, neither did the supplementation hinder strength measures or body composition variables in either group. From a practical perspective, longer term (9.5 weeks) creatine supplementation combined with resistance training does not appear to give experienced resistance trained females a physiological advantage to strength measures or body composition, and therefore, would not be recommended by the author of this study as an ergogenic aid without further research.

4.3 Future Research

Ten weeks of creatine monohydrate supplementation does not appear to significantly improve body composition or strength indices greater than resistance training alone. Further research must be conducted before the complete effects of

creatine supplementation as an ergogenic aid in relation to females can be understood. Research regarding creatine supplementation and females are scarce, and the studies that have been completed vary widely in terms of physiological variables measured, and the length of time the studies were performed. The present study made an attempt to include a few important variables that female athletes may be concerned with; one being strength measures, and secondly, body composition.

The current study investigated the effects of 9.5 weeks of creatine supplementation in order to correspond with the length of one term of university studies. It may be possible that this length of time was insufficient in order for the ergogenic effects of creatine supplementation to be made apparent.

Furthermore, the present study used experienced resistance trained females (one year of resistance training experience at least 2 to 3 times per week) as participants. This definition may be too broad and the criteria to meet 'experienced' may have to be made more stringent. Ideally, it would have been advantageous to have the participants on a strict resistance training program for a period of weeks or months before the initiation of the study, in order to reduce variability and a 'training effect' in 1 RM strength measures. However, considering the population of the study, this would be extremely difficult to achieve and maintain participant adherence.

The present study used urinary analysis to determine indirectly, the creatine uptake within the muscle. Ideally, muscle biopsies would be preeminent but was not possible to conduct during this study. For future research, it would be very interesting and advantageous to interpret baseline creatine content levels intramuscularly and determine skeletal fibre typing uptake. Forsberg (1991) did

conclude that females tend to have an increased creatine content within skeletal muscle, and delving further into this concept could facilitate in determining if creatine monohydrate is indeed an ergogenic aid for the female population.

Finally, the 70% 1 RM 5 set repeat protocol may not be satisfactory in determining if creatine monohydrate does aid in recovery during latter sets when resistance training. For this population, 70% of the 1 RM did not seem to elicit the repetition range that was anticipated, when considering the bench press and incline leg press exercises. For future research, a greater percentage of 1 RM may be needed to ensure the work to rest ratio is more reflective of the ATP-PC system demands and recovery.

4.4 Conclusion

The results of the present study indicate that creatine monohydrate supplementation combined with resistance training did not significantly improve strength measures or body composition over training alone, nor did it elicit the creatine group to be able to perform an increased amount of training volume. Thus, there is no evidence to support an ergogenic effect for strength measures or body composition measured in this study, when ingesting creatine in combination with resistance training over a 9.5 week period in experienced resistance trained females. Additional research is needed in order to further examine the potential of creatine monohydrate as a supplement for performance enhancement in females before it can be recommended as an ergogenic aid.

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APPENDIX

APPENDIX A

APPENDIX B

Physical Activity Readiness Questionnaire - PAR-Q (revised 2002)

PAR-Q & YOU

(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

YES	NO		
☐	☐	1.	**Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?**
☐	☐	2.	**Do you feel pain in your chest when you do physical activity?**
☐	☐	3.	**In the past month, have you had chest pain when you were not doing physical activity?**
☐	☐	4.	**Do you lose your balance because of dizziness or do you ever lose consciousness?**
☐	☐	5.	**Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?**
☐	☐	6.	**Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?**
☐	☐	7.	**Do you know of any other reason why you should not do physical activity?**

If you answered YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

NO to all questions

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

- start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal – this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

DELAY BECOMING MUCH MORE ACTIVE:

- If you are not feeling well because of a temporary illness such as a cold or a fever – wait until you feel better; or
- If you are or may be pregnant – talk to your doctor before you start becoming more active.

PLEASE NOTE: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

Informed Use of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

No changes permitted. You are encouraged to photocopy the PAR-Q but only if you use the entire form.

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

"I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction."

NAME _____

SIGNATURE _____ DATE _____

SIGNATURE OF PARENT or GUARDIAN (for participants under the age of majority) _____ WITNESS _____

Note: This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.

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APPENDIX C

CREATINE SUPPLEMENTATION STUDY – INITIAL QUESTIONNAIRE

NAME: _____ **AGE:** _____

CONTACT INFORMATION: Phone #: _____ e-mail: _____

Please answer the following questions with honesty – it is important that we get the most qualified participants for this study.

1/ Please explain your weight-training history. How many years, and how many times per week on average?

_____

_____

2/ Are you pregnant or planning on becoming pregnant from September, 2003 to December, 2003? Yes ____ No ____

3/ Do you eat poultry, pork, red meat, or fish? Yes ____ No ____
If yes, how often? daily ___ every other day ___ 2-3x/week ___ once a week ____

4/ Have you been taking any form of nutritional supplement (protein, creatine, glutamine, etc.) within the past 6 weeks? Yes ____ No ____
If yes, please specify_____

5/ Have you had a barium swallow or nuclear medicine scan in the past 3 weeks?
Yes ____ No ____

6/ What recreational activities are you currently involved in, and what may you be involved in over the next 4 months? Please list activity(s) and how many times per week.

_____

_____

7/ Are you planning on training for any other type of activity/ sport over the next 4 months? Yes ____ No ____ If yes, please specify _____

_____

8/ Are you currently taking birth control? Yes ____ No ____ If yes, what type?

_____

9/ 100% adherence to the resistance training program is important to the results of the study. Are you willing to following the resistance training program outlined in this study for the 9.5 week period – remember, no additional exercises can be added to the program.
Yes ____ No ____

10/ Caffeine has been shown to reduce the body's ability to absorb creatine. Are you willing to refrain from any caffeine product for the first 7 days (the loading phase) of the study? Yes ____ No ____

APPENDIX D

weeks and eat a mixed diet, you may eligible to be in the study. Participants must have at least one year of weight training experience (2-3 sessions per week on a regular basis). Total time completion for this study will be twelve weeks.

You will be randomized into one of the two groups. One group will receive creatine in solution everyday for 9.5 weeks. The other group will receive a polycose placebo powder in a solution that looks and tastes similar to the creatine supplement. It is important that **caffeine must not be taken at the same time as creatine**, as it may prevent creatine from being taken into the muscle. During the loading phase, which will be the first seven days of the study, all subjects will be required **not to consume any caffeine**, since the creatine supplement will be taken every four hours (8 A.M., 12 noon, 4 P.M., 8 P.M.). After the loading phase, you will be taking your supplements twice daily, once before your workout, and then once after. During this time, you will be able to consume caffeine, just not at the same time as your supplement.

You will be required to participate in a weight training program four days per week for a total of 34 workouts, during the 9.5 weeks. The program is split to work the upper body on Mondays and Thursdays while the legs and abdominals will be targeted on Tuesdays and Fridays. Wednesdays, Saturdays and Sundays will normally be rest days. All strength testing will take place in the Varsity weight room in the Faculty of Physical Education and Recreation building. Body composition (DEXA) will be measured at the University of Alberta's Department of Agricultural, Food and Nutritional Science.

During the pre and post testing, your body composition will be measured using dual energy x-ray absorptiometry (DEXA). The DEXA measures your fat mass, fat-free mass (muscle, bones, organs and tissues), and bone density. You will be required to wear a hospital gown and lie quietly for approximately 5 minutes as an external scan is taken of your entire body. **You will be required to provide a mandatory urine sample** before the DEXA scan to make sure you are not pregnant. Pregnant women will not be allowed to partake in the study. You will be excluded if you have recently undergone a nuclear medicine scan or a barium swallow within the last 3 weeks. Please refer to the DEXA scan subject protocol at the back of the letter for more information.

There will be a total of four 24-hour urine samples that will be collected throughout the study (one before the training begins, after the 7-day loading phase, at the 5-week period, and at the end of the 9.5-week training/supplementation phase). On the specified Sundays (found on your calendar) you will be asked to collect all your urine over the 24-hour period in a bottle. This urine collection will begin with the second urination on the specified Sunday. All urinations on that Sunday and your first urination on the Monday must be collected. The urine bottles can be turned in to the Biochemistry Lab (E-443) on the fourth floor of the Faculty of Physical Education and Recreation.

During the pre test, midway through the study (at 5 weeks) and after the study is completed; you will do a one repetition maximum (1 RM) test that measures your absolute muscular strength. You will be tested on the bench press and incline leg press with 1.5 minutes of rest between sets. You will be asked to do a second test, which will

be 5 sets of 70% of your 1 RM. The recovery period between these sets will be 75 seconds. During this test you will be required to complete as many repetitions as possible for each set. There will be about 48 hours of rest in between the 1 RM test and the 70% 1 RM test. You will be asked to avoid doing any type of strenuous activity for about 36 hours before any physical testing. This is also to ensure that a maximal strength score will be reached.

During the pre, mid-point and post testing sessions you will be asked to complete a survey asking how you feel about your physical self and your exercise self-efficacy. The first and last survey will be completed at the DEXA appointments. The mid-point survey will be completed at your midpoint strength test.

You will also be required to fill in a 3-day dietary food record pre-test and post-test, which will be analyzed by a researcher. This will be used to look at any dietary changes that may happen throughout the study.

Time Commitment:	Pre/ post DEXA: 15 minutes/ session	= 0.5 hr
	Pre/ post psychological questionnaire: 15 min/ session	= 0.5 hr
	Pre/ mid/ post 1 RM measures = 0.75 hrs/ session	= 2.25 hrs
	Pre/ mid/ post 70% 1 RM measures = 0.75 hrs/ session	= 2.25 hrs
	Pre/ mid/ post 3 day dietary log = 1 hr/ day x 9 days	= 9 hrs
	Training = 1.5 hrs/ day, 4 days/ wk for 10 wks	= 60 hrs
	24 hr urine collection samples x 4 = 0.25 hrs/ day	= 1 hr
	Total time commitment = 75.5 hrs over a 12-week period	
	(Not including travel to and from, changing and showering)	

Benefits: Benefits of this study include the possibility that your strength and muscle mass will increase, however these benefits are not guaranteed. You will get a dietary analysis, based on your reported 3-day dietary records, which will show the amount of carbohydrates, protein, fat and total calories you are consuming in your regular diet.

A great benefit to the study is the DEXA scans. This information gives you detailed information regarding muscle mass in grams, fat (based as a percent and grams) and bone mineral density. The information is broken down into arm, torso and leg sections for both the left and right sides of the body.

This study will provide the researchers with data regarding physical and psychological results of the strength training program and supplementation use.

Risks: Possible risks with strength training include muscle pulls or strains if improper lifting techniques are utilized. Correct instruction of lifting techniques, and a warm-up and cool down before and after each training session will help reduce these risks. Risks associated with 1 RM lifts include temporary high blood pressure and light-headedness due to the intensity of the maximal tests. While serious risks to healthy participants are highly unlikely, they must be presented, and participants must willingly assume the risks related with very hard exercise. The principal investigator and the graduate student

SEPTEMBER 2003

94

Sun	Mon	Tue	Wed	Thu	Fri	Sat
	1	2	3 CLASSES BEGIN	4	5	6
7	8	9 ORIENTATION MEETING	10 NO PHYSICAL ACTIVITY (NO P.A.)	11 1 RM TESTING NO P.A.	12 1 RM TESTING NO P.A.	13 NO P.A.
14 1st 24 hr URINE SAMPLE NO P.A. 3	15 70% 1 RM TESTING NO P.A DAY DIETARY	16 70% 1 RM TESTING NO P.A. LOG	17	18	19 TEST/RETEST DEXA SCANS/ SURVEY	20 DEXA SCANS/ SURVEY
21	22 DAY 1 LOADING PH UPPER BODY	23 DAY 2 LOADING PH LOWER BODY	24 DAY 3 LOADING PH REST DAY	25 DAY 4 LOADING PH UPPER BODY	26 DAY 5 LOADING PH LOWER BODY	27 DAY 6 LOADING PH REST DAY
28 DAY 7 LOADING PH 2nd 24 HR URINE SAMPLE	29 DAY 1 MAINT PH UPPER BODY	30 DAY 2 MAINT PH LOWER BODY				

OCTOBER 2003

95

Sun	Mon	Tue	Wed	Thu	Fri	Sat
			1 DAY 3 MAINT PH REST DAY	2 DAY 4 MAINT PH UPPER BODY	3 DAY 5 MAINT PH LOWER BODY	4 DAY 6 MAINT PH REST DAY
5 DAY 7 MAINT PH REST DAY	6 DAY 8 MAINT PH UPPER BODY	7 DAY 9 MAINT PH LOWER BDDY	8 DAY 10 MAINT PH REST DAY	9 DAY 11 MAINT PH UPPER BODY	10 DAY 12 MAINT PH LOWER BODY	11 DAY 13 MAINT PH REST DAY
12 DAY 14 MAINT PH REST DAY	13 DAY 15 MAINT PH THANKSGIVING REST DAY	14 DAY 16 MAINT PH UPPER BODY	15 DAY 17 MAINT PH LOWER BODY	16 DAY 18 MAINT PH REST DAY	17 DAY 19 MAINT PH UPPER BODY	18 DAY 20 MAINT PH LOWER BODY
19 DAY 21 MAINT PH REST DAY	20 DAY 22 UPPER BODY + 70% 1 RM FOR BENCH PRESS	21 DAY 23 LOWER BODY + 70% 1 RM FOR ILP	22 DAY 24 MAINT PH NO P.A.	23 DAY 25 MAINT PH 1 RM TESTING	24 DAY 26 MAINT PH 1 RM TESTING	25 DAY 27 MAINT PH REST DAY
26 DAY 28 MAINT PH 3RD 24 HR URINE SAMPLE	27 DAY 29 MAINT PH 70% 1 RM TEST	28 DAY 30 MAINT PH 70% 1 RM TEST	29 DAY 31 MAINT PH REST DAY	30 DAY 32 MAINT PH UPPER BODY	31 DAY 33 MAINT PH LOWER BODY	

NOVEMBER 2003

Sun	Mon	Tue	Wed	Thu	Fri	Sat
						1 DAY 34 MAINT PH REST DAY
2 DAY 35 MAINT PH REST DAY	3 DAY 36 MAINT PH UPPER BODY	4 DAY 37 MAINT PH LOWER BODY	5 DAY 38 MAINT PH REST DAY	6 DAY 39 MAINT PH UPPER BODY	7 DAY 40 MAINT PH LOWER BODY	8 DAY 41 MAINT PH REST DAY
9 DAY 42 MAINT PH REST DAY	10 DAY 43 MAINT PH HOLIDAY-REST	11 DAY 44 MAINT PH HOLIDAY-REST	12 DAY 45 MAINT PH UPPER BODY	13 DAY 46 MAINT PH LOWER BODY	14 DAY 47 MAINT PH UPPER BODY	15 DAY 48 MAINT PH LOWER BODY
16 DAY 49 MAINT PH REST DAY	17 DAY 50 MAINT PH UPPER BODY	18 DAY 51 MAINT PH LOWER BODY	19 DAY 52 MAINT PH REST DAY	20 DAY 53 MAINT PH UPPER BODY	21 DAY 54 MAINT PH LOWER BODY	22 DAY 55 MAINT PH REST DAY
23 DAY 56 MAINT PH REST DAY	24 DAY 57 UPPER BODY+ BP 70% 1 RM	25 DAY 58 LOWER BODY + 70% 1RM ILP	26 NO PHYSICAL ACTIVITY	27 I RM TESTING NO P.A.	28 1 RM TESTING NO P.A.	29 NO PHYSICAL ACTIVITY
30 4TH 24 HR URINE SAMPLE NO P.A.						

DECEMBER 2003

97

Sun	Mon	Tue	Wed	Thu	Fri	Sat
3	1 70% 1 RM TESTING NO P.A. DAY DIETARY	2 70% 1 RM TESTING NO P.A. LOG	3 LAST DAY OF CLASSES	4	5 TEST-RETEST DEXA SCANS/ SURVEY	6 DEXA SCANS/ SURVEY
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

APPENDIX E

APPENDIX F

APPENDIX G

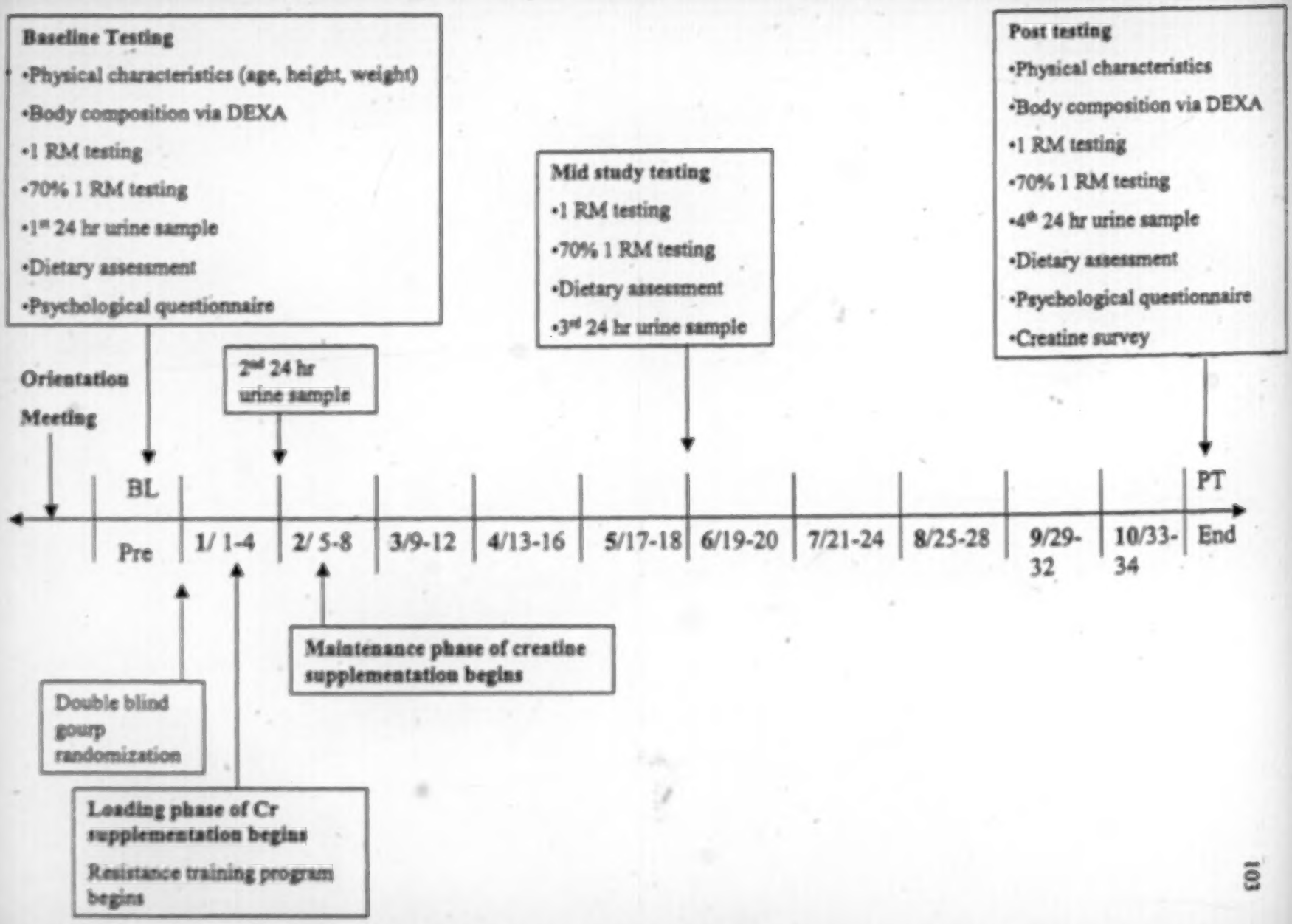

Fig. 1. Schematic timeline of all measurements being taken over the 12 week time period

APPENDIX II

APPENDIX I

I RM TESTING

DATE: _____

NAME: _____

DAY OF PILL or DAY OR MENSTRAUL CYCLE: _____

TESTING PROTOCOL

1/ Warm-up on bicycle for a minimum of 5 minutes
2/ Stretch muscles that will be tested – chest and legs
3/ A 2.5 minute rest will be given between each set – it is important to use this recovery time to allow the ATP-PC stores to recover, so that your next lift will be maximal.
4/ **1st set –** is a warm up set – select a weight at which you can easily do 10 repetitions
2nd set – select a weight that you feel confident that you could repeat 3 times
3rd set - select a weight at which you could only lift the load one time
- you will have a maximum of 3 attempts to find your true 1 RM score
5/ Your spotter will help you with the lift-off
6/ For the bench press you must maintain a 5-point contact throughout the lift – this means your head, shoulders and buttocks must remain on the bench, while feet remain on the floor - you will lower the bar to your chest, pause momentarily, and then press the bar vertically until the elbows are fully extended – this is one repetition
7/ During the incline leg press you must place your feet shoulder width apart on a standardized black line – hands may not be placed on the thighs – this will not count as a repetition if they are
Your knees will be measured at a 90° angle with a goniometer, and the distance will be marked on the side of the machine – this way you will know how far to lower the plate to complete one repetition

BENCH PRESS 1 RM TEST: **TESTER(s):** _____

200% Biacromial breadth (cm): _____ _____

1 RM (lbs): _____

INCLINE LEG PRESS 1 RM TEST: **TESTER(s):** _____

Distance in cm: _____ _____

1 RM (lbs): _____

70% 1 RM TESTING

DATE: _____

NAME: _____

DAY OF PILL or MENSTRAUL CYCLE: _____

1/ Warm-up on bicycle for a minimum of 5 minutes
2/ Stretch muscles that will be tested – chest and legs
3/ A 75 sec rest will be given between each set – it is important to use this recovery time to allow the ATP-PC stores to recover, so that your next lift will be accurate
4/ 70% of your 1 RM will be added, and you will lift this weight as many times as possible, following the proper technique that was outlined in the 1 RM protocol over 5 sets.

BENCH PRESS 70% 1 RM TEST: **TESTER(s):** _____

200% Biacromial breadth (cm): _____ _____

70% 1 RM LOAD (lbs): _____

NUMBER OF REPS: **SET 1** _____
SET 2 _____
SET 3 _____
SET 4 _____
SET 5 _____

INCLINE LEG PRESS 70% 1 RM TEST: **TESTER(s):** _____

Distance in cm: _____ _____

70% 1 RM LOAD (lbs): _____

NUMBER OF REPS: **SET 1** _____
SET 2 _____
SET 3 _____
SET 4 _____
SET 5 _____

APPENDIX J

STUDY TESTING TIMES

Record the times you will be doing your testing throughout the study on this sheet, and keep it in your workout log. That way you will always know what times and days you are doing the testing.

All 1 RM and 70% 1 RM testing will be conducted in the varsity weight room (the 70% 1 RM testing you will be doing on your own can be done in your own fitness facility – Oct 20-21 and Nov 24-25)

Sept 11 & 12 (Thursday/ Friday) – 1 RM TESTING
Date: _____ Time: _____

Sept 15 & 16 (Monday/ Tuesday) – 70% 1 RM TESTING
Date: _____ Time: _____

Sept 19 & 20 (Friday/ Saturday) – DEXA SCANS AND QUESTIONNAIRES
Date: _____ Time: _____

Oct 23 & 24 (Thursday/ Friday) – 1 RM TESTING
Date: _____ Time: _____

Oct 27 & 28 (Monday/ Tuesday) – 70% 1 RM TESTING
Date: _____ Time: _____

Nov 27 & 28 (Thursday/ Friday) – 1 RM TESTING
Date: _____ Time: _____

Dec 1 & 2 (Monday/ Tuesday) – 70% 1 RM TESTING
Date: _____ Time: _____

Dec 5 & 6 (Friday/ Saturday) – DEXA SCANS AND QUESTIONNAIRE
Date: _____ Time: _____

WEEKS 1-2

- 3 sets of 10-12 reps (warm-up set not included)

THINGS TO REMEMBER:

- loading phase is 7 days (Sept. 22-28)
- take the supplement 4x a day
- on Sept. 28 (last day of loading phase) you must perform your 2nd 24 hour urine sample
- remember, this begins with your 2nd urination Sunday morning, followed by ALL urinations that day, including your 1st urination Monday morning – then you will hand in your collection Monday morning to the P.E Biochemistry Lab (4th floor E-443)
- maintenance phase begins Sept. 29
- take your supplement 2x a day

UPPER BODY WORKOUT

EXERCISE	SETS REQUIRED	REPS REQUIRED	REPS COMPLETED				WEIGHT (plates or weight)			
Bench press	3	10-12								
Lat pulldown	3	10-12								
Military press (barbell or dumbbells)	3	10-12								
Seated row (machine or cable)	3	10-12								
Incline bench press	3	10-12								
Upright row (barbell, cable or dumbbells)	3	10-12								
Bicep curl (with straight bar or barbell)	3	10-12								
Tricep extensions (with rope or bar)	3	10-12								

FITNESS FACILITY SUPERVISOR SIGNATURE: _____

DATE SIGNED: _____

PLEASE MENTION ANY SIDE EFFECTS YOU MAY BE EXPERIENCING TODAY:

_____
_____
_____
_____
_____

ANY COMMENTS OR SUGGESTIONS ABOUT WORKOUT TODAY (ie. Felt tired, not enough sleep last night, exercises too easy, too hard, etc.)

_____
_____
_____
_____
_____

LOWER BODY WORKOUT

EXERCISE	SETS REQUIRED	REPS REQUIRED	REPS COMPLETED				WEIGHT (plates or weight)			
Smith machine squats	3	10-12								
Incline leg press	3	10-12								
Stiff-legged deadlifts	3	10-12								
Lunges (with barbell or dumbbells)	3	10-12								
Abdominal crunches	3	To exhaustion								
Reverse curls	3	To exhaustion								
Oblique crunches	3	To exhaustion								

FITNESS FACILITY SUPERVISOR SIGNATURE: _____

DATE SIGNED: _____

PLEASE MENTION ANY SIDE EFFECTS YOU MAY BE EXPERIENCING TODAY:

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ANY COMMENTS OR SUGGESTIONS ABOUT WORKOUT TODAY (ie. Felt tired, not enough sleep last night, exercises too easy, too hard, etc.)

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WEEKS 3-5

- 4 sets of 10-12 reps (warm-up set not included)

THINGS TO REMEMBER:

- During the 5th week, you must do your own 70% 1 RM with the initial weight you did during your test – get someone to help you with spotting and timing you in between sets – record the repetitions for each set on the specific 70% 1 RM page
- You get 75 sec of rest in between each of the 5 sets – try to be as accurate as possible with this!
- On Oct. 20 – your upper body workout plus the 70% 1 RM (5 sets), perform this bench press test first – then continue with the rest of your workout
- On Oct. 21 – your lower body workout plus the 70% 1 RM (5 sets), perform the incline leg press first – then continue with the rest of your workout (make sure to record the number of reps completed)
- On Oct. 23 & 24, you will be doing your 1 RM testing in the Varsity weight room – make sure you are well rested!

UPPER BODY WORKOUT

EXERCISE	SETS REQUIRED	REPS REQUIRED	REPS COMPLETED				WEIGHT (plates or weight)			
Bench press	4	10-12								
Lat pulldown	4	10-12								
Military press (barbell or dumbbells)	4	10-12								
Seated row (machine or cable)	4	10-12								
Incline bench press	4	10-12								
Upright row (barbell, cable or dumbbells)	4	10-12								
Bicep curl (with straight bar or barbell)	4	10-12								
Tricep extensions (with rope or bar)	4	10-12								

FITNESS FACILITY SUPERVISOR SIGNATURE: _____

DATE SIGNED: _____

PLEASE MENTION ANY SIDE EFFECTS YOU MAY BE EXPERIENCING TODAY:

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ANY COMMENTS OR SUGGESTIONS ABOUT WORKOUT TODAY (ie. Felt tired, not enough sleep last night, exercises too easy, too hard, etc.)

_____

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LOWER BODY WORKOUT

EXERCISE	SETS REQUIRED	REPS REQUIRED	REPS COMPLETED				WEIGHT (plates or weight)			
Smith machine squats	4	10-12								
Incline leg press	4	10-12								
Stiff-legged deadlifts	4	10-12								
Lunges (with barbell or dumbbells)	4	10-12								
Abdominal crunches	4	To exhaustion								
Reverse curls	4	To exhaustion								
Oblique crunches	4	To exhaustion								

FITNESS FACILITY SUPERVISOR SIGNATURE: _____

DATE SIGNED: _____

PLEASE MENTION ANY SIDE EFFECTS YOU MAY BE EXPERIENCING TODAY:

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ANY COMMENTS OR SUGGESTIONS ABOUT WORKOUT TODAY (ie. Felt tired, not enough sleep last night, exercises too easy, too hard, etc.)

_____

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_____

_____

_____

70 % 1 RM TESTING

75 sec of rest between sets – please be as accurate as possible with these times

OCT 20 – BENCH PRESS

	SET 1	SET 2	SET 3	SET 4	SET 5
# of reps					
weight					

OCT 21 – INCLINE LEG PRESS

	SET 1	SET 2	SET 3	SET 4	SET 5
# of reps					
weight					

WEEKS 6-8

- 4 sets of 8-10 reps

THINGS TO REMEMBER

- on Oct. 26 you will be doing your 3rd 24 hr urine collection
- begin with your 2nd urination Sunday morning, followed by ALL urinations that day – include the 1st urination of Monday morning, then hand in your collection to the P.E Biochemistry Lab (E-443)
- We will be performing your new 70% 1 RM's on Oct. 27 & 28 with your new 1 RM that we took a couple of days previously
- Nov 10 & 11 are holidays at the U of A, but if your fitness facility is open, then go ahead and perform the week like you normally would

UPPER BODY WORKOUT

EXERCISE	SETS REQUIRED	REPS REQUIRED	REPS COMPLETED				WEIGHT (plates or weight)			
Bench press	4	8-10								
Lat pulldown	4	8-10								
Military press (barbell or dumbbells)	4	8-10								
Seated row (machine or cable)	4	8-10								
Incline bench press	4	8-10								
Upright row (barbell, cable or dumbbells)	4	8-10								
Bicep curl (with straight bar or barbell)	4	8-10								
Tricep extensions (with rope or bar)	4	8-10								

FITNESS FACILITY SUPERVISOR SIGNATURE: _____

DATE SIGNED: _____

PLEASE MENTION ANY SIDE EFFECTS YOU MAY BE EXPERIENCING TODAY:

_____

_____

_____

_____

_____

ANY COMMENTS OR SUGGESTIONS ABOUT WORKOUT TODAY (ie. Felt tired, not enough sleep last night, exercises too easy, too hard, etc.)

_____

_____

_____

_____

_____

LOWER BODY WORKOUT

EXERCISE	SETS REQUIRED	REPS REQUIRED	REPS COMPLETED				WEIGHT (plates or weight)			
Smith machine squats	4	8-10								
Incline leg press	4	8-10								
Stiff-legged deadlifts	4	8-10								
Lunges (with barbell or dumbbells)	4	8-10								
Abdominal crunches	4	To exhaustion								
Reverse curls	4	To exhaustion								
Oblique crunches	4	To exhaustion								

FITNESS FACILITY SUPERVISOR SIGNATURE: _____

DATE SIGNED: _____

PLEASE MENTION ANY SIDE EFFECTS YOU MAY BE EXPERIENCING TODAY:

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ANY COMMENTS OR SUGGESTIONS ABOUT WORKOUT TODAY (ie. Felt tired, not enough sleep last night, exercises too easy, too hard, etc.)

_____
_____
_____
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_____

WEEKS 9-10

- 5 sets of 6-8 reps (warm-up set not included)

THINGS TO REMEMBER:

- Nov. 24 is upper body workout, plus your initial 70% 1 RM bench press test – remember do this exercise first
- Get someone to help you spot and to keep track of recovery time in between your 5 sets (75 sec) – be accurate!
- Nov. 25 is lower body workout – do ILP first, then continue with the rest of your workout – remember to record the reps
- Nov 27 & 28 is 1 RM testing – make sure you are well rested (Varsity weight room again)
- Nov. 30 will be your last 24 hr urine sample! Follow the same protocol as the previous times
- Dec. 1 & 2 are 70% 1 RM testing of your new 1 RMs that you did on the 27/28
- DEXAs will be on Dec. 5 & 6
- Your done the study!

UPPER BODY WORKOUT

EXERCISE	SETS REQUIRED	REPS REQUIRED	REPS COMPLETED					WEIGHT (plates or weight)				
Bench press	5	6-8										
Lat pulldown	5	6-8										
Military press (barbell or dumbbells)	5	6-8										
Seated row (machine or cable)	5	6-8										
Incline bench press	5	6-8										
Upright row (barbell, cable or dumbbells)	5	6-8										
Bicep curl (with straight bar or barbell)	5	6-8										
Tricep extensions (with rope or bar)	5	6-8										

FITNESS FACILITY SUPERVISOR SIGNATURE: _____

DATE SIGNED: _____

PLEASE MENTION ANY SIDE EFFECTS YOU MAY BE EXPERIENCING TODAY:

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ANY COMMENTS OR SUGGESTIONS ABOUT WORKOUT TODAY (ie. Felt tired, not enough sleep last night, exercises too easy, too hard, etc.)

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LOWER BODY WORKOUT

EXERCISE	SETS REQUIRED	REPS REQUIRED	REPS COMPLETED					WEIGHT (plates or weight)				
Smith machine squats	5	6-8										
Incline leg press	5	6-8										
Stiff-legged deadlifts	5	6-8										
Lunges (with barbell or dumbbells)	5	6-8										
Abdominal crunches	5	To exhaustion										
Reverse curls	5	To exhaustion										
Oblique crunches	5	To exhaustion										

FITNESS FACILITY SUPERVISOR SIGNATURE: _____

DATE SIGNED: _____

PLEASE MENTION ANY SIDE EFFECTS YOU MAY BE EXPERIENCING TODAY:

_____
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_____

ANY COMMENTS OR SUGGESTIONS ABOUT WORKOUT TODAY (ie. Felt tired, not enough sleep last night, exercises too easy, too hard, etc.)

_____
_____
_____
_____
_____

70 % 1 RM TESTING

75 sec of rest between sets – please be as accurate as possible with these times

NOV 24 – BENCH PRESS

	SET 1	SET 2	SET 3	SET 4	SET 5
# of reps					
weight					

NOV 25 – INCLINE LEG PRESS

	SET 1	SET 2	SET 3	SET 4	SET 5
# of reps					
weight					

APPENDIX K

APPENDIX L

CREATINE SUPPLEMENTATION SURVEY

Thank you again for participating in the study. Please take a few minutes to answer the following questions.

After participating in the study, which group do you believe you were a part of? (circle one)

Creatine supplement group Control (placebo) group

Please explain why you think you were in that group:

Please list any side effects that you may have experienced while ingesting the supplement that occurred at any time during the study (this would be any condition that you have never experienced from your normal workout routine while not taking any type of nutritional supplement).

If you have any comments about the study please list them below:

Tina Ferguson,

Principle Investigator

APPENDIX M

Human Nutrition Research Centre

3-11 Agriculture/Forestry Centre, Dept. of Agricultural Food & Nutritional Science
University of Alberta, Edmonton, AB, T6G 2P5

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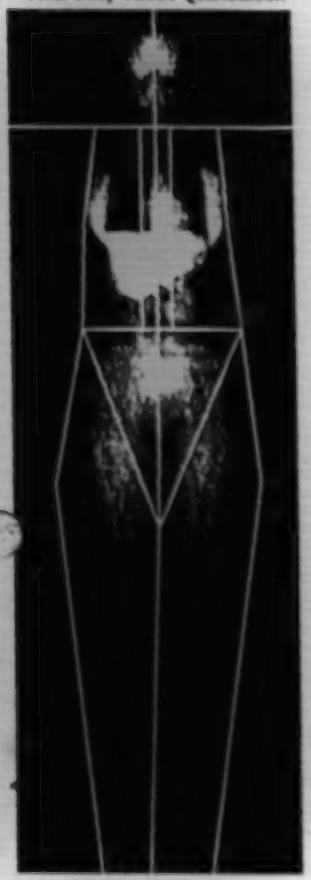
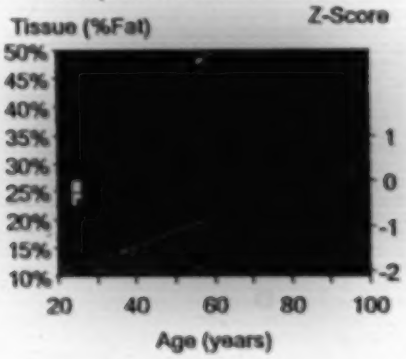
Patient:		**Patient ID:**	04-B		
Birth Date:	25.1 years	**Physician:**	DK		
Height / Weight:	65.0 in. 136.7 lbs.	**Measured:**	06/12/2003	12:55:20 PM	(6.70)
Sex / Ethnic:	Female White	**Analyzed:**	06/12/2003	12:57:05 PM	(6.70)

Total Body Tissue Quantitation

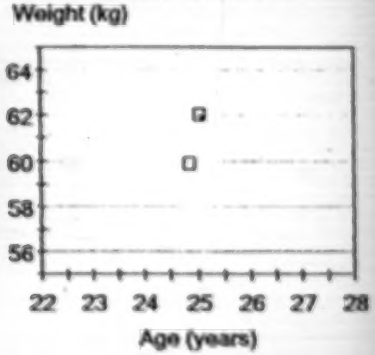


COMMENTS:

Composition Reference: Total



Trend Weight: Total



Region	Tissue (%Fat)	Z-Score [2,3]	T.Mass (kg)	Fat (g)	Lean (g)	BMC (g)
Left Arm	16.3	-	-	527	2,699	163
Left Leg	27.6	-	-	3,036	7,950	443
Left Trunk	23.6	-	-	3,337	10,799	374
Right Arm	16.3	-	-	526	2,696	160
Right Leg	27.6	-	-	2,976	7,795	457
Right Trunk	23.6	-	-	3,184	10,308	355
Arms	16.3	-	-	1,053	5,395	324
Legs	27.6	-	-	6,012	15,745	899
Trunk	23.6	-	-	6,521	21,107	729
Total	23.6	-0.6	62.1	14,080	45,557	2,423

Trend: Total

Measured Date	Age (years)	Tissue (%Fat)	Z-Score [2,3]	T.Mass (kg)	Fat (g)	Lean (g)
DGC 06/12/2003	25.0	23.6	-0.6	62.1	14,080	45,557
SEPT 19/09/2003	24.8	25.8	-0.3	60.0	14,887	42,712
		-2.2%		+2.1kg	-807	+2845

Image not for diagnosis

Printed: 06/12/2003 12:57:15 PM (6.70) 76:0.15:153.85:31.2 0.00:-1.00
4.80x13.00 10.6%Fat=23.6%
0.00:0.00 0.00:0.00
Filename: Stud_hghsfspy0.dfb
Scan Mode: Standard

2 -USA, Total Body Reference Population
3 -Matched for Age

GE Medical Systems
LUNAR

Prodigy
DF+14184

Human Nutrition Research Centre

3-11 Agriculture/Forestry Centre, Dept. of Agricultural Food & Nutritional Science
University of Alberta, Edmonton, AB, T6G 2P5

Patient:			**Patient ID:**	04-8	
Birth Date:		25.1 years	**Physician:**	DK	
Height / Weight:	65.0 in.	136.7 lbs.	**Measured:**	06/12/2003	12:55:20 PM (6.70)
Sex / Ethnic:	Female	White	**Analyzed:**	06/12/2003	12:57:05 PM (6.70)

ANCILLARY RESULTS [Total Body]

Region	BMD [1] (g/cm²)	Young-Adult [2] (%)	Young-Adult [2] T-Score	Age-Matched [3] (%)	Age-Matched [3] Z-Score	BMC (g)	Area (cm²)
Head	2.148	-	-	-	-	470	219
Arms	0.899	-	-	-	-	324	360
Legs	1.307	-	-	-	-	899	688
Trunk	0.943	-	-	-	-	729	774
Ribs	0.667	-	-	-	-	197	295
Pelvis	1.167	-	-	-	-	309	265
Spine	1.046	-	-	-	-	224	214
Total	1.187	106	0.8	106	0.8	2,423	2,041

BODY COMPOSITION

Region	Tissue (%Fat)	Region (%Fat)	Tissue (g)	Fat (g)	Lean (g)	BMC (g)	Total Mass (kg)
Left Arm	16.3	15.6	3,227	527	2,699	163	-
Left Leg	27.6	26.6	10,986	3,036	7,950	443	-
Left Trunk	23.6	23.0	14,135	3,337	10,799	374	-
Left Total	23.6	22.7	30,223	7,144	23,080	1,211	-
Right Arm	16.3	15.5	3,222	526	2,696	160	-
Right Leg	27.6	26.5	10,771	2,976	7,795	457	-
Right Trunk	23.6	23.0	13,493	3,184	10,308	355	-
Right Total	23.6	22.6	29,414	6,937	22,478	1,212	-
Arms	16.3	15.5	6,448	1,053	5,395	324	-
Legs	27.6	26.5	21,757	6,012	15,745	899	-
Trunk	23.6	23.0	27,628	6,521	21,107	729	-
Total	23.6	22.7	59,638	14,080	45,557	2,423	62.1

1 -Statistically 68% of repeat scans fall within 1SD (± 0.010 g/cm² for Total Body Total)
2 -USA, Total Body Reference Population, Ages 20-40
3 -Matched for Age
Filename: tbad_hpholquy0.dfb

APPENDIX N

Sample Meal

Food and Beverage Items	Description Of Item	No. Of Units	Unit Of Measure
Enter all foods and beverages consumed. For combination foods, please include detailed information on each item.	Include a detailed description of each food and drink item consumed including: - Brand name - Flavour - Method of cooking - All other relevant information on food/drink label	Enter number of units	Enter unit of measure: for example: cup, grams, ounce, piece, teaspoon, tablespoon
Spaghetti with tomato/meat sauce:			
Pasta	Spaghetti, cooked	2	Cup
Tomato sauce	Hunt's canned sauce, roasted garlic flavour	1	Cup
Meat balls	Made with extra lean ground beef	5	Number (1 oz/ball)
Parmesan cheese, grated	Kraft, 30% Milk Fat (M.F.)	1	Tablespoon
Garlic Bread:			
Italian Bread	Toasted	3	Piece (large slice)
Garlic Butter		3	Teaspoon
Caesar salad:			
Lettuce	Romaine	1	Cup
Croutons	Safeway brand, garlic flavor	2	Tablespoon
Bacon bits	Simulated flavour, No Name Brand	2	Tablespoon
Caesar salad dressing	Kraft, Fat free	2	Tablespoon
Milk	1%	1	Cup
Tiramisu	Sarah Lee	1	Slice
Coffee	Black	1	Cup

Vitamin/Mineral Supplements or Herbal Products taken: _____

Fill in blanks: Time of meal/snack: 6:00 pm **Location meal/snack was consumed:** at home

Please CHECK (✓) if you did not eat or drink at this meal or snack time: _____

Day 1 - Morning Meal

FOOD AND BEVERAGE ITEMS	DESCRIPTION OF ITEM	NO. OF UNITS	UNIT OF MEASURE
Enter all foods and beverages consumed. For combination foods, please include detailed information on each item.	Include a detailed description of each food and drink item consumed including: - Brand name - Flavour - Method of cooking - All other relevant information on food/drink label	Enter number of units	Enter unit of measure: for example: cup, grams, ounce, piece, teaspoon, tablespoon

Vitamin/Mineral Supplements or Herbal Products taken:_____

_____

Fill in blanks: Time of meal/snack:_____ **Location meal/snack was consumed:**_____

Please CHECK (✓) if you did not eat or drink at this meal or snack time:_____

Day 1 - Mid-Morning Snack

FOOD AND BEVERAGE ITEMS	DESCRIPTION OF ITEM	NO. OF UNITS	UNIT OF MEASURE
Enter all foods and beverages consumed. For combination foods, please include detailed information on each item.	Include a detailed description of each food and drink item consumed including: - Brand name - Flavour - Method of cooking - All other relevant information on food/drink label	Enter number of units	Enter unit of measure: for example: cup, grams, ounce, piece, teaspoon, tablespoon

Vitamin/Mineral Supplements or Herbal Products taken:_____

Fill in blanks: Time of meal/snack:_____ **Location meal/snack was consumed:**_____

Please CHECK (✓) if you did not eat or drink at this meal or snack time:_____

Day 1 - Midday Meal

FOOD AND BEVERAGE ITEMS	DESCRIPTION OF ITEM	NO. OF UNITS	UNIT OF MEASURE
Enter all foods and beverages consumed. For combination foods, please include detailed information on each item.	Include a detailed description of each food and drink item consumed including: - Brand name - Flavour - Method of cooking - All other relevant information on food/drink label	Enter number of units	Enter unit of measure: for example: cup, grams, ounce, piece, teaspoon, tablespoon

Vitamin/Mineral Supplements or Herbal Products taken:_____

Fill in blanks: Time of meal/snack:_____ **Location meal/snack was consumed:**_____

Please CHECK (✓) if you did not eat or drink at this meal or snack time:_____

Day 1 - Afternoon Snack

FOOD AND BEVERAGE ITEMS	DESCRIPTION OF ITEM	NO. OF UNITS	UNIT OF MEASURE
Enter all foods and beverages consumed. For combination foods, please include detailed information on each item.	Include a detailed description of each food and drink item consumed including: - Brand name - Flavour - Method of cooking - All other relevant information on food/drink label	Enter number of units	Enter unit of measure: for example: cup, grams, ounce, piece, teaspoon, tablespoon

Vitamin/Mineral Supplements or Herbal Products taken:_____

_____

Fill in blanks: Time of meal/snack:_____ **Location meal/snack was consumed:**_____

Please CHECK (✓) if you did not eat or drink at this meal or snack time:_____

Day 1 - Evening Meal

FOOD AND BEVERAGE ITEMS	DESCRIPTION OF ITEM	NO. OF UNITS	UNIT OF MEASURE
Enter all foods and beverages consumed. For combination foods, please include detailed information on each item.	Include a detailed description of each food and drink item consumed including: - Brand name - Flavour - Method of cooking - All other relevant information on food/drink label	Enter number of units	Enter unit of measure: for example: cup, grams, ounce, piece, teaspoon, tablespoon

Vitamin/Mineral Supplements or Herbal Products taken:_____

_____

Fill in blanks: Time of meal/snack:_____ **Location meal/snack was consumed:**_____

Please CHECK (✓) if you did not eat or drink at this meal or snack time:_____

Day 1 - Evening Snack

FOOD AND BEVERAGE ITEMS	DESCRIPTION OF ITEM	NO. OF UNITS	UNIT OF MEASURE
Enter all foods and beverages consumed. For combination foods, please include detailed information on each item.	Include a detailed description of each food and drink item consumed including: - Brand name - Flavour - Method of cooking - All other relevant information on food/drink label	Enter number of units	Enter unit of measure: for example: cup, grams, ounce, piece, teaspoon, tablespoon

Vitamin/Mineral Supplements or Herbal Products taken:_____

Fill in blanks: Time of meal/snack:_____ **Location meal/snack was consumed:**_____

Please CHECK (✓) if you did not eat or drink at this meal or snack time:_____

APPENDIX O

CREATINE & CREATININE

Bernt, E., Bergmeyer, H.U., and Mollering, H. "Methods of enzymatic analysis". Edited by H.U. Bergmeyer. PP 1772-1776. Academic Press, New York, 1974.

creatinine + H_2O → creatine (enzyme being creatininase)

creatine + ATP → PCr + ADP (enzyme being creatine kinase)

ADP + PEP → ATP + pyr (enyme being pyruvate kinase)

Pyr + NADH + H^+ → lactate + NAD^+ (enzyme being lactic dehydrogenase)

- NADH absorbs light at 340 nm (1mM NADH = 6.22 A)
- buy LDH, PK, and creatininase in 50% glycerol

SOLUTIONS:

1. Glycine/ PO_4 Buffer

(0.1 M glycine, 0.1 M Na_2HPO_4, 0.2% Triton X-100, pH 8.0)
-dissolve 1.88g glycine and 6.70g Na_2HPO_4 $7H_2O$ in 200ml dH_2O
-add 0.5ml Triton X-100
-pH to 8.0 with HCl and dilute to 250ml

2. 1 M $MgCl_2$ $6H_2O$

-dissolve 2.03g $MgCl_2$ $6H_2O$ and make up to 10 ml

3. NADH/ ATP/ PEP

(2mM NADH, 5.5mM ATP, 6mM PEP, 0.1 M glycylglycine buffer, pH 8.0)
-dissolve 660mg glyclyglycine in 40ml dH_2O
-adjust to pH 8.0 with NaOH
-add 83mg ß-NADH- Na_2
-add 170mg ATP- Na_2 3 H_2O
-add 142g PEP $(CHA)_3$
-check pH and dilute to 50ml with dH_2O

4. LDH/PK – (700U/ ml LDH : 300U/ml PK)

-dilute stock suspensions with 50% glycerol

5. 0.5% $NaHCO_3$

-dissolve 0.25g $NaHCO_3$
-for #7

6. CK (1500U/ml)

-dissolve 75mg protein in ml 0.5% $NaHCO_3$
-if necessary, centrifuge off the precipitate

7. Creatininase (500 U/ml)
-dilute stock with 50% glycerol accordingly

Sample (urine)
-must be diluted 1:49 with dH_2O

*Add #7 after 10-15 minutes incubation (to start the reaction)

Read E_1 immediately – E_2 exactly 30 min later – E_3 10 min after that (for drift)

$\Delta E = (E_1 - E_2) - 3(E_2 - E_3)$

[creatinine] = Δ E x 1.035 (µmole/ml)

***spin urine sample for 3-4 min at maximum rpm before adding to cuvette**